CS 305 Lab Tutorial
Lab11 IPv4 & ICMPv4

Dept. Computer Science and Engineering

Southern University of Science and Technology

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Thanks to Wei WANG

Topic

- IPv4
  - Best effort, IP address, IP fragment and assemble
- ICMPv4
  - Detect and report
- IPv6
  - The difference between IPv4 and IPv6

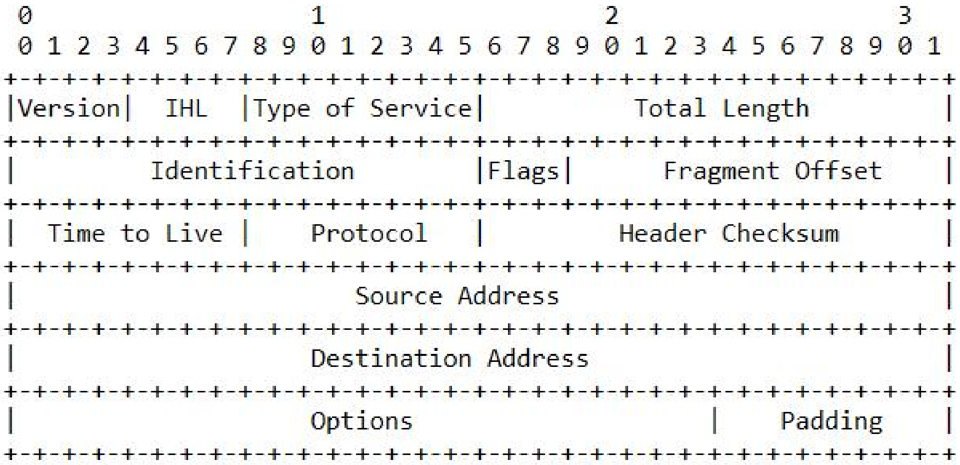
Part A. IPv4

- **Best effort** : NO connection, NO flow control, NO congestion control, NO retransmission...

- The internet protocol implements two basic functions: **addressing** and **fragmentation**.
  - The internet modules use the addresses carried in the internet header to transmit internet datagrams toward their destinations. The selection of a path for transmission is called **routing**.
  - The internet modules use fields in the internet header to **fragment** and **reassemble** internet datagrams when necessary for transmission through "small packet" networks. The model of operation is that an internet module resides in each host engaged in internet communication and in each gateway that interconnects networks.

https://tools.ietf.org/html/rfc791

IPv4 Datagram



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service|          Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Identification        |Flags|      Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live |    Protocol   |         Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Address                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Example Internet Datagram Header

- **Type of Service:**

The major choice is a three way tradeoff between low-delay, high-reliability, and high-throughput.

- **Time to Live (TTL):**

an indication of an upper bound on the lifetime of an internet datagram. **It is set by the sender of the datagram and reduced at the points along the route where it is processed.** An IP datagram with zero TTL will be dropped.

- **Header Checksum:**

provides a verification that the information used in processing internet datagram has been transmitted correctly. The data may contain errors. If the header checksum fails, the internet datagram is discarded at once by the entity which detects the error.

- **Options:**

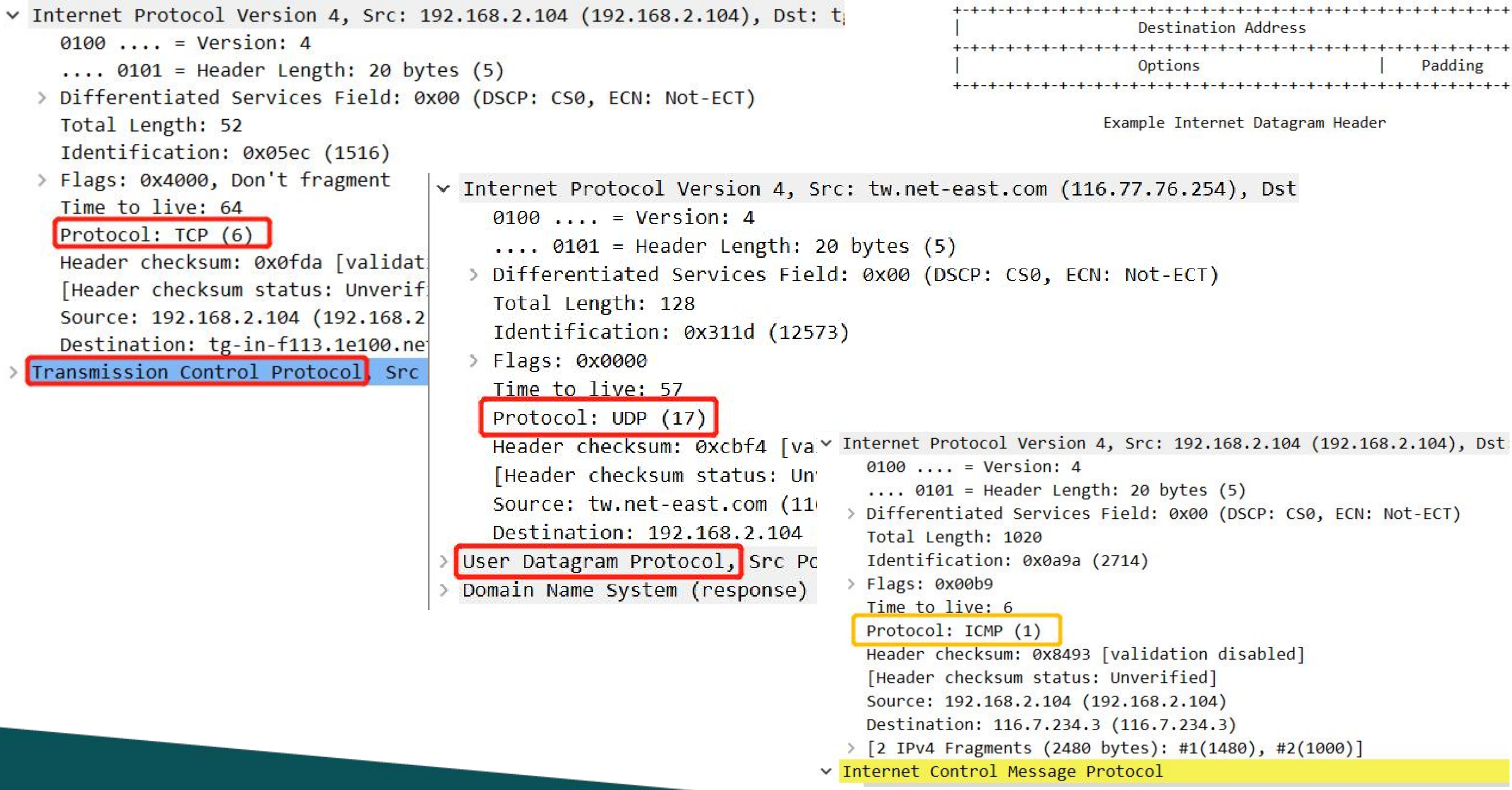
provide for control functions needed or useful in some situations but unnecessary for the most common communications. The options include provisions for timestamps, security, and special routing.

https://tools.ietf.org/html/rfc791

Protocol Field

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Version|  IHL  |Type of Service|          Total Length         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         Identification        |Flags|      Fragment Offset    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Time to Live |    Protocol   |         Header Checksum       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Source Address                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Destination Address                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Options                    |    Padding    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Example Internet Datagram Header



```
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: t
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 52
    Identification: 0x05ec (1516)
  > Flags: 0x4000, Don't fragment
    Time to live: 64
    Protocol: TCP (6)
    Header checksum: 0x0fda [validat
    [Header checksum status: Unverif
    Source: 192.168.2.104 (192.168.2
    Destination: tg-in-f113.1e100.ne
> Transmission Control Protocol, Src
```

```
v Internet Protocol Version 4, Src: tw.net-east.com (116.77.76.254), Dst
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 128
    Identification: 0x311d (12573)
  > Flags: 0x0000
    Time to live: 57
    Protocol: UDP (17)
    Header checksum: 0xcbf4 [va
    [Header checksum status: Un
    Source: tw.net-east.com (11
    Destination: 192.168.2.104
> User Datagram Protocol, Src Po
> Domain Name System (response)
```

```
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 1020
    Identification: 0x0a9a (2714)
  > Flags: 0x00b9
    Time to live: 6
    Protocol: ICMP (1)
    Header checksum: 0x8493 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.104 (192.168.2.104)
    Destination: 116.7.234.3 (116.7.234.3)
  > [2 IPv4 Fragments (2480 bytes): #1(1480), #2(1000)]
v Internet Control Message Protocol
```

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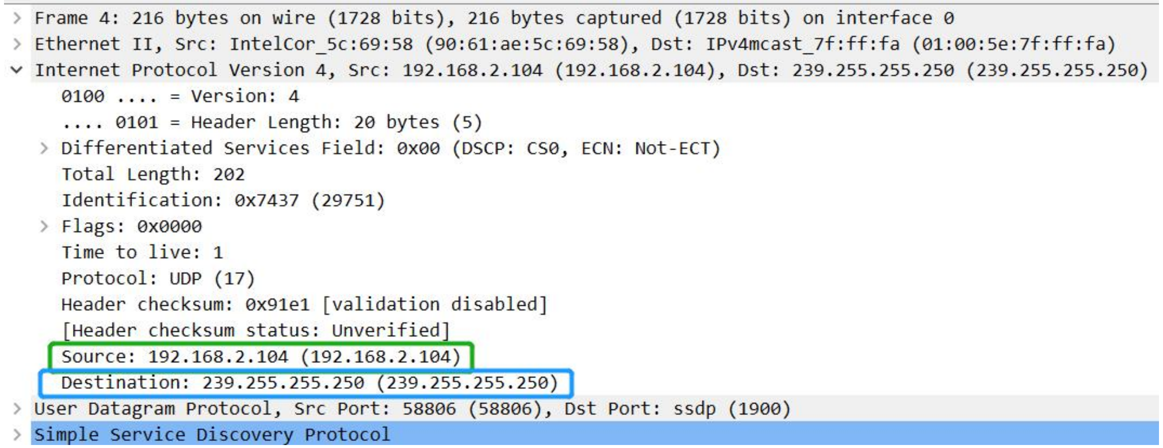
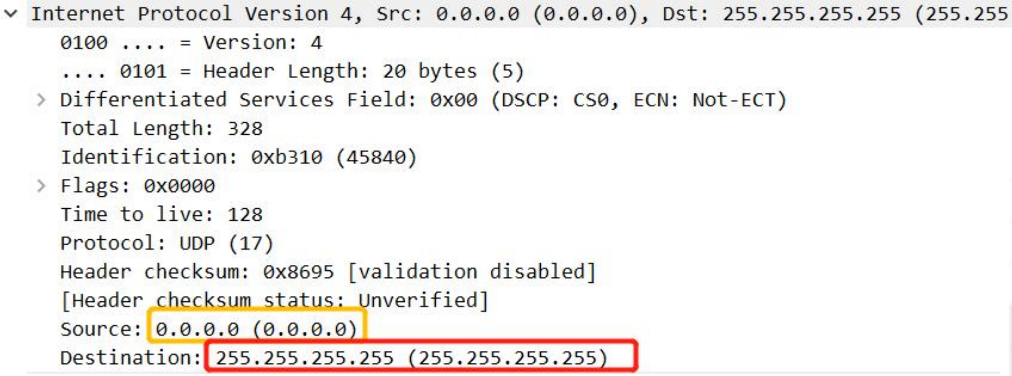
Source and Destination Field



```
> Frame 4: 216 bytes on wire (1728 bits), 216 bytes captured (1728 bits) on interface 0
> Ethernet II, Src: IntelCor_5c:69:58 (90:61:ae:5c:69:58), Dst: IPv4mcast_7f:ff:fa (01:00:5e:7f:ff:fa)
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: 239.255.255.250 (239.255.255.250)
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 202
    Identification: 0x7437 (29751)
  > Flags: 0x0000
    Time to live: 1
    Protocol: UDP (17)
    Header checksum: 0x91e1 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.104 (192.168.2.104)
    Destination: 239.255.255.250 (239.255.255.250)
> User Datagram Protocol, Src Port: 58806 (58806), Dst Port: ssdp (1900)
> Simple Service Discovery Protocol
```



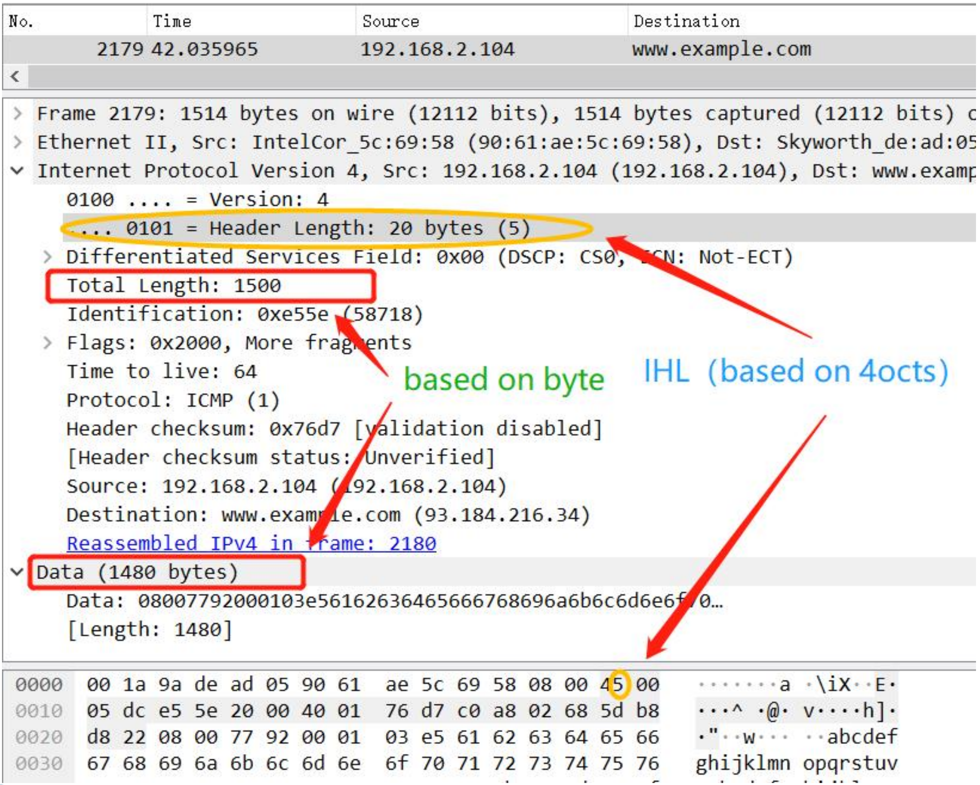
```
v Internet Protocol Version 4, Src: 0.0.0.0 (0.0.0.0), Dst: 255.255.255.255 (255.255.255.255)
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 328
    Identification: 0xb310 (45840)
  > Flags: 0x0000
    Time to live: 128
    Protocol: UDP (17)
    Header checksum: 0x8695 [validation disabled]
    [Header checksum status: Unverified]
    Source: 0.0.0.0 (0.0.0.0)
    Destination: 255.255.255.255 (255.255.255.255)
```

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service|          Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Identification        |Flags|      Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live |    Protocol   |         Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Address                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Example Internet Datagram Header

IHL and Total Length

Initial the session with following cmd command: ping www.example.com –l 2000



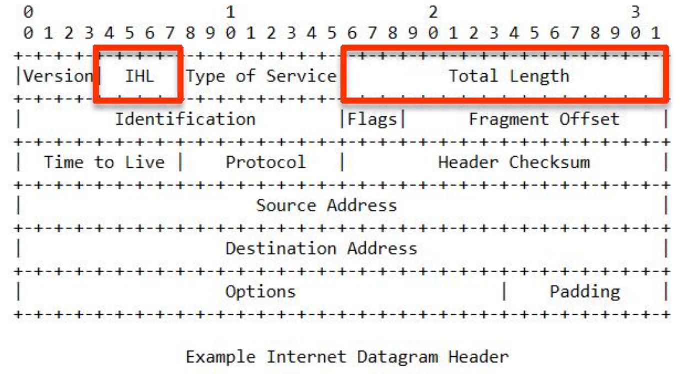
```
No.        Time              Source              Destination
   2179 42.035965           192.168.2.104       www.example.com

> Frame 2179: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) c
> Ethernet II, Src: IntelCor_5c:69:58 (90:61:ae:5c:69:58), Dst: Skyworth_de:ad:05
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: www.examp
     0100 .... = Version: 4
     .... 0101 = Header Length: 20 bytes (5)
   > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
     Total Length: 1500
     Identification: 0xe55e (58718)
   > Flags: 0x2000, More fragments
     Time to live: 64
     Protocol: ICMP (1)
     Header checksum: 0x76d7 [validation disabled]
     [Header checksum status: Unverified]
     Source: 192.168.2.104 (192.168.2.104)
     Destination: www.example.com (93.184.216.34)
     Reassembled IPv4 in frame: 2180
v Data (1480 bytes)
     Data: 08007792000103e56162636465666768696a6b6c6d6e6f70…
     [Length: 1480]

0000  00 1a 9a de ad 05 90 61  ae 5c 69 58 08 00 45 00   ·······a ·\iX··E·
0010  05 dc e5 5e 20 00 40 01  76 d7 c0 a8 02 68 5d b8   ···^ ·@· v····h]·
0020  d8 22 08 00 77 92 00 01  03 e5 61 62 63 64 65 66   ·"··w··· ··abcdef
0030  67 68 69 6a 6b 6c 6d 6e  6f 70 71 72 73 74 75 76   ghijklmn opqrstuv
```

IHL: 4 bits

Internet **H**eader **L**ength is the length of the internet header in 32 bit words, and thus points to the beginning of the data. Note that the minimum value for a correct header is 5.

Total Length: 16 bits

the length of the datagram, measured in octets, including internet header and data.



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service|          Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Identification        |Flags|      Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live |    Protocol   |         Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Address                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                 Example Internet Datagram Header
```

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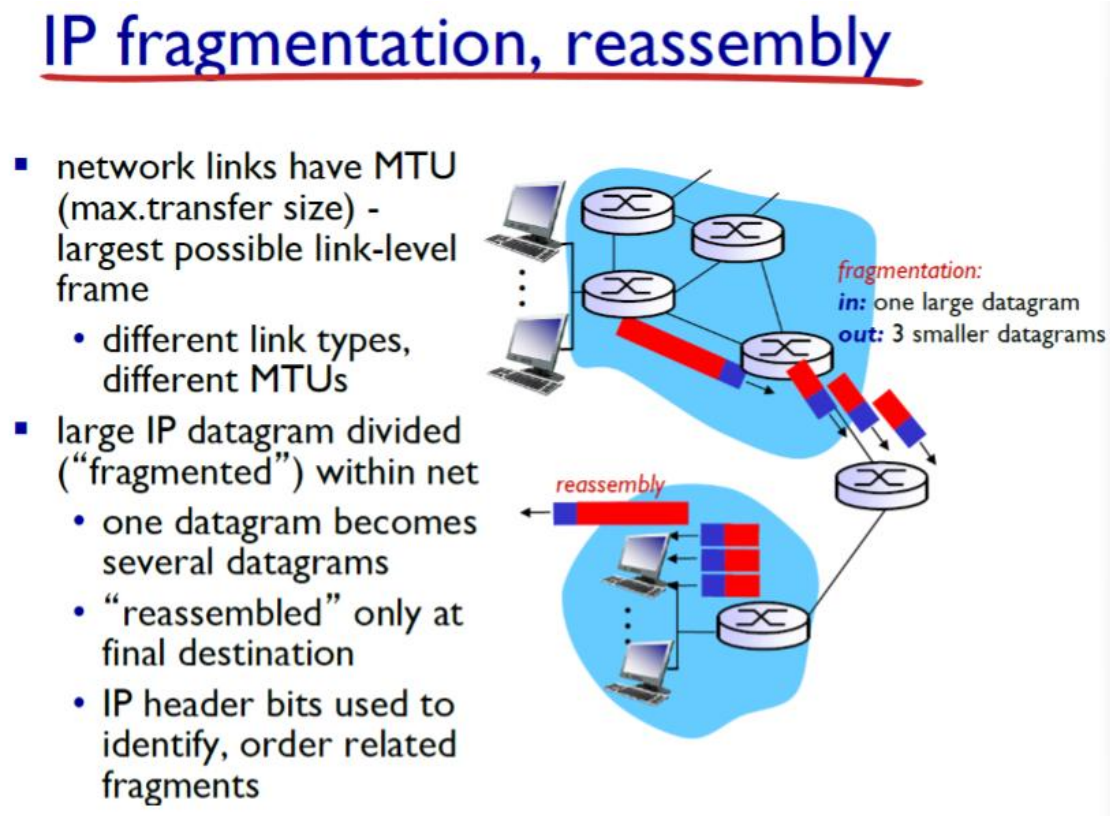
IP Fragmentation and Reassembly



IP fragmentation, reassembly

- network links have MTU (max.transfer size) - largest possible link-level frame
  - different link types, different MTUs
- large IP datagram divided (“fragmented”) within net
  - one datagram becomes several datagrams
  - “reassembled” only at final destination
  - IP header bits used to identify, order related fragments

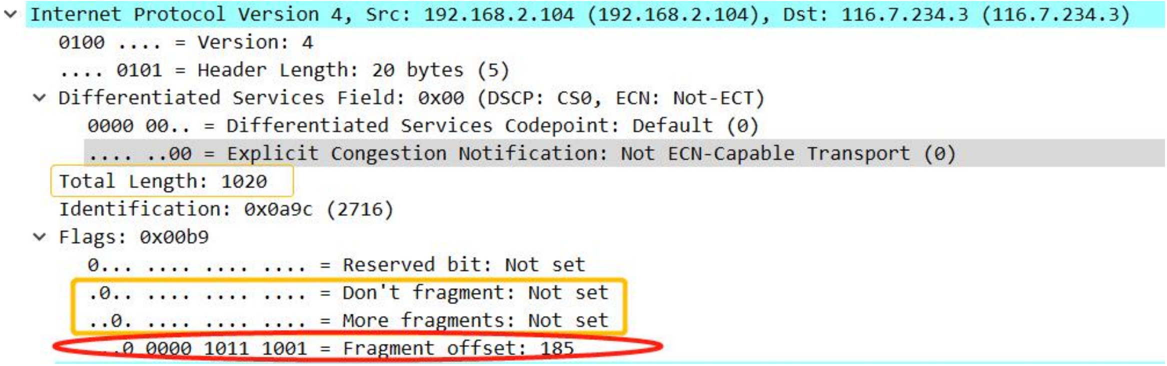
fragmentation:
in: one large datagram
out: 3 smaller datagrams

reassembly

IP Fragment(1)

```
Flags:  3 bits

  Various Control Flags.

    Bit 0: reserved, must be zero
    Bit 1: (DF) 0 = May Fragment,  1 = Don't Fragment.
    Bit 2: (MF) 0 = Last Fragment, 1 = More Fragments.

        0   1   2
      +---+---+---+
      |   | D | M |
      | 0 | F | F |
      +---+---+---+
```

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Version|  IHL  |Type of Service|          Total Length         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         Identification        |Flags|      Fragment Offset    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Time to Live |    Protocol   |         Header Checksum       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Source Address                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Destination Address                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Options                    |    Padding    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                    Example Internet Datagram Header
```



```
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: 116.7.234.3 (116.7.234.3)
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  v Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      0000 00.. = Differentiated Services Codepoint: Default (0)
      .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 1020
    Identification: 0x0a9c (2716)
  v Flags: 0x00b9
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..0. .... .... .... = More fragments: Not set
      ...0 0000 1011 1001 = Fragment offset: 185
```

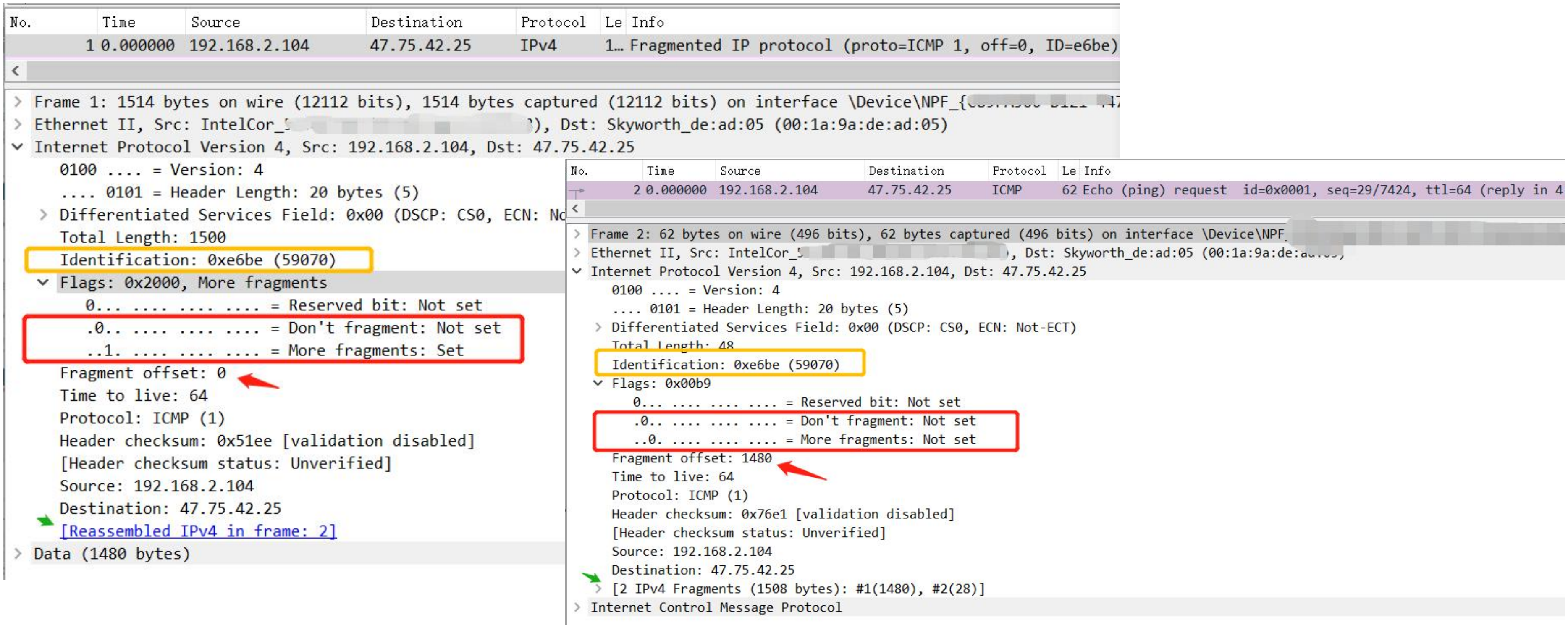
Fragment Offset: 13 bits

This field indicates where in the datagram this fragment belongs.
The fragment offset is measured **in units of 8 octets** (64 bits). The first fragment has offset zero.

Tips in Wireshark :   ip.flags.mf

IP Fragment(2)

Initial the session with following cmd command: ping www.example.cn   –l   _?_



```
No.     Time      Source          Destination   Protocol  Le Info
      1 0.000000  192.168.2.104   47.75.42.25   IPv4      1… Fragmented IP protocol (proto=ICMP 1, off=0, ID=e6be)

> Frame 1: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface \Device\NPF_{[redacted]
> Ethernet II, Src: IntelCor_[redacted]), Dst: Skyworth_de:ad:05 (00:1a:9a:de:ad:05)
v Internet Protocol Version 4, Src: 192.168.2.104, Dst: 47.75.42.25
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: No
    Total Length: 1500
    Identification: 0xe6be (59070)
  v Flags: 0x2000, More fragments
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..1. .... .... .... = More fragments: Set
    Fragment offset: 0
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0x51ee [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.104
    Destination: 47.75.42.25
    [Reassembled IPv4 in frame: 2]
> Data (1480 bytes)
```

```
No.     Time      Source          Destination   Protocol  Le Info
      2 0.000000  192.168.2.104   47.75.42.25   ICMP      62 Echo (ping) request  id=0x0001, seq=29/7424, ttl=64 (reply in 4

> Frame 2: 62 bytes on wire (496 bits), 62 bytes captured (496 bits) on interface \Device\NPF_[redacted]
> Ethernet II, Src: IntelCor_[redacted]), Dst: Skyworth_de:ad:05 (00:1a:9a:de:[redacted]
v Internet Protocol Version 4, Src: 192.168.2.104, Dst: 47.75.42.25
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 48
    Identification: 0xe6be (59070)
  v Flags: 0x00b9
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..0. .... .... .... = More fragments: Not set
    Fragment offset: 1480
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0x76e1 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.104
    Destination: 47.75.42.25
  > [2 IPv4 Fragments (1508 bytes): #1(1480), #2(28)]
> Internet Control Message Protocol
```

Identification: An internet header field carrying the identifying value assigned by the sender to aid in assembling the fragments of a datagram.

Tips in Wireshark : ip.id

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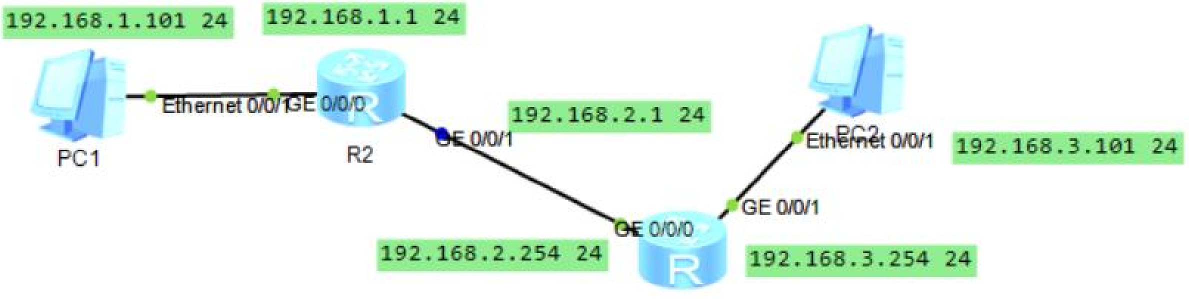
Demo1 - IP fragment(1)

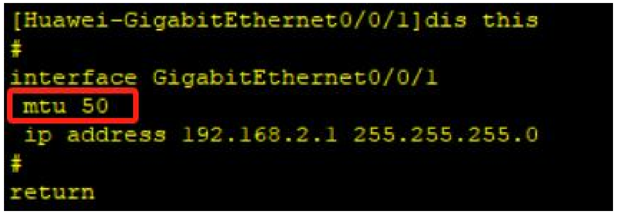
Build the network as the topology shown on the right hand, after the configuration, PC1 could send/receive the pkt to/from PC2.

Tips: in eNSP, router support IP fragment while PC don’t.

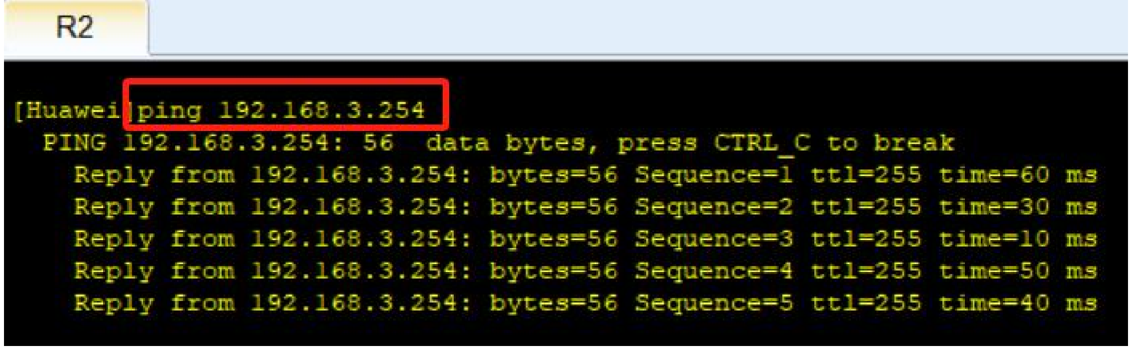
Set the the MTU of R2’s interface GE0/0/1 as **50**.

Invoke “ping” test on R2, and capture the packet ont its interface GE 0/0/1





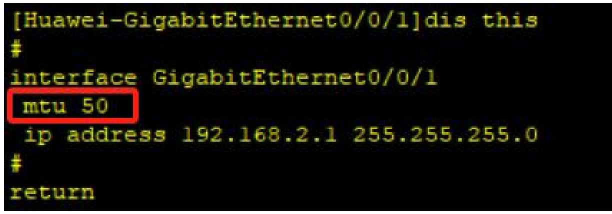
```
[Huawei-GigabitEthernet0/0/1]dis this
#
interface GigabitEthernet0/0/1
 mtu 50
 ip address 192.168.2.1 255.255.255.0
#
return
```



```
[Huawei]ping 192.168.3.254
  PING 192.168.3.254: 56  data bytes, press CTRL_C to break
    Reply from 192.168.3.254: bytes=56 Sequence=1 ttl=255 time=60 ms
    Reply from 192.168.3.254: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 192.168.3.254: bytes=56 Sequence=3 ttl=255 time=10 ms
    Reply from 192.168.3.254: bytes=56 Sequence=4 ttl=255 time=50 ms
    Reply from 192.168.3.254: bytes=56 Sequence=5 ttl=255 time=40 ms
```

Tips: in eNSP, route support IP fragment while PC don’t.

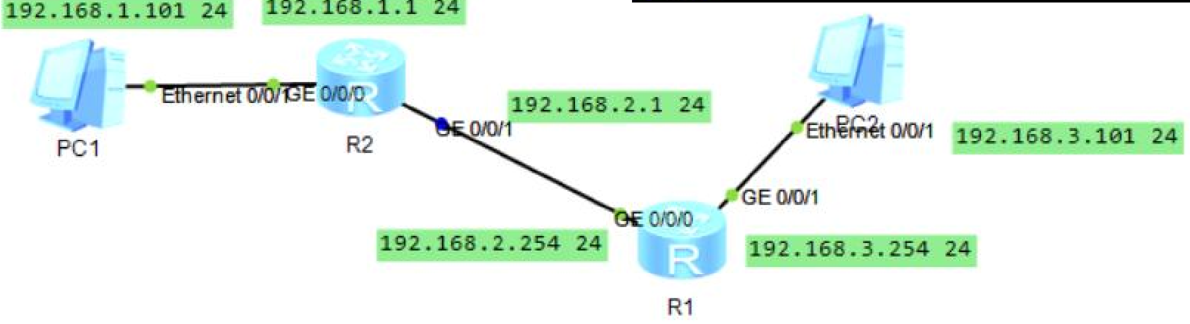
Demo1 - IP fragment(2)

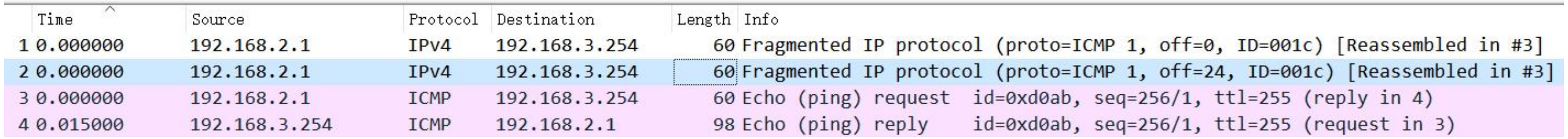


```
[Huawei-GigabitEthernet0/0/1]dis this
#
interface GigabitEthernet0/0/1
 mtu 50
 ip address 192.168.2.1 255.255.255.0
#
return
```

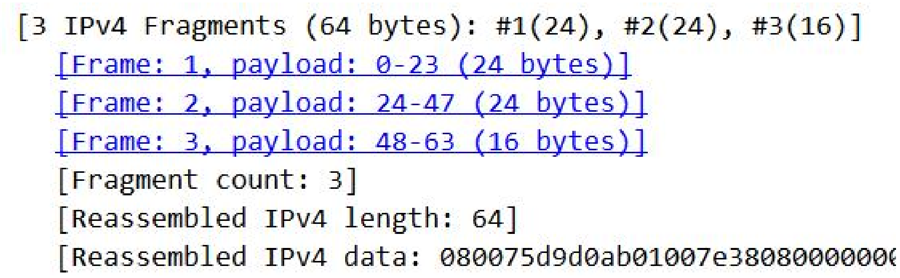
The MTU of R2’s interface GE0/0/1 is set as 50.

Invoke “ping” test on R2, and capture the packet ont its interface GE 0/0/1





```
  Time        Source          Protocol Destination    Length Info
1 0.000000    192.168.2.1     IPv4     192.168.3.254      60 Fragmented IP protocol (proto=ICMP 1, off=0, ID=001c) [Reassembled in #3]
2 0.000000    192.168.2.1     IPv4     192.168.3.254      60 Fragmented IP protocol (proto=ICMP 1, off=24, ID=001c) [Reassembled in #3]
3 0.000000    192.168.2.1     ICMP     192.168.3.254      60 Echo (ping) request  id=0xd0ab, seq=256/1, ttl=255 (reply in 4)
4 0.015000    192.168.3.254   ICMP     192.168.2.1        98 Echo (ping) reply    id=0xd0ab, seq=256/1, ttl=255 (request in 3)
```



```
[3 IPv4 Fragments (64 bytes): #1(24), #2(24), #3(16)]
   [Frame: 1, payload: 0-23 (24 bytes)]
   [Frame: 2, payload: 24-47 (24 bytes)]
   [Frame: 3, payload: 48-63 (16 bytes)]
   [Fragment count: 3]
   [Reassembled IPv4 length: 64]
   [Reassembled IPv4 data: 080075d9d0ab01007e3808000000
```

Q1: As shown in the packet 1-4, only the packet send by 192.168.2.1 is fraged, the packet it received is not, why?

Q2： How does the Wireshak identify the order of each fragment in an IP packet ?

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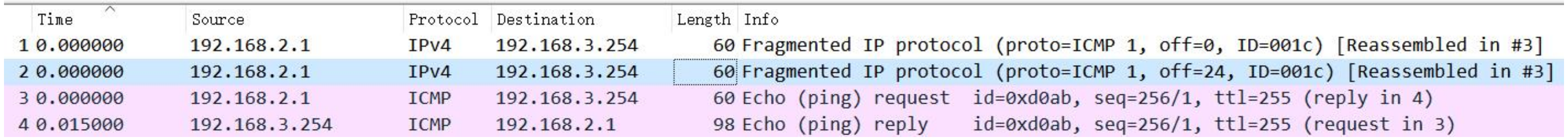
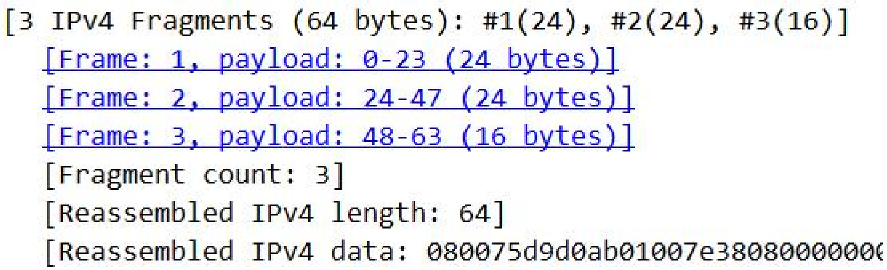
Demo1 - IP fragment(3)



	Time	Source	Protocol	Destination	Length	Info
1	0.000000	192.168.2.1	IPv4	192.168.3.254	60	Fragmented IP protocol (proto=ICMP 1, off=0, ID=001c) [Reassembled in #3]
2	0.000000	192.168.2.1	IPv4	192.168.3.254	60	Fragmented IP protocol (proto=ICMP 1, off=24, ID=001c) [Reassembled in #3]
3	0.000000	192.168.2.1	ICMP	192.168.3.254	60	Echo (ping) request id=0xd0ab, seq=256/1, ttl=255 (reply in 4)
4	0.015000	192.168.3.254	ICMP	192.168.2.1	98	Echo (ping) reply id=0xd0ab, seq=256/1, ttl=255 (request in 3)



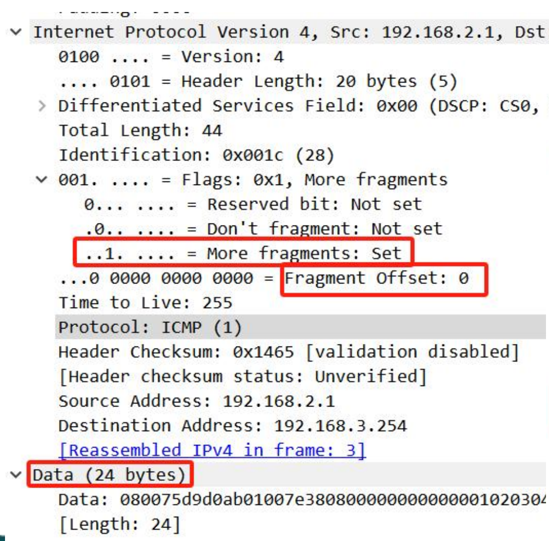
```
[3 IPv4 Fragments (64 bytes): #1(24), #2(24), #3(16)]
  [Frame: 1, payload: 0-23 (24 bytes)]
  [Frame: 2, payload: 24-47 (24 bytes)]
  [Frame: 3, payload: 48-63 (16 bytes)]
  [Fragment count: 3]
  [Reassembled IPv4 length: 64]
  [Reassembled IPv4 data: 080075d9d0ab01007e38080000000
```

Q2: How does the Wireshak identify the order of each fragment in an IP packet ?

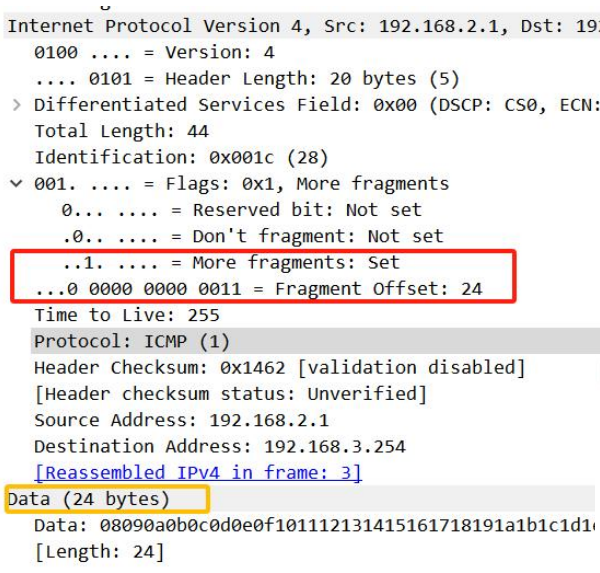
A2: Flags in the IP header:

1) More flagments
0: not the last piece
1: the last piece

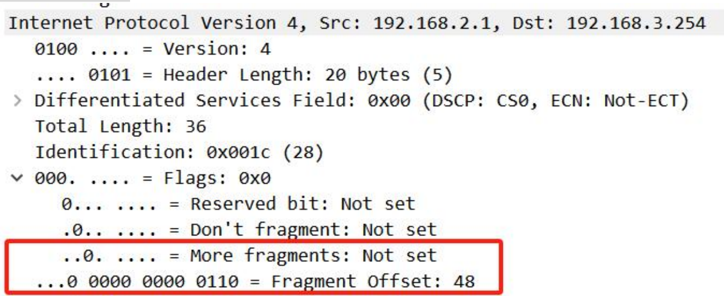
2) Fragment offset
0: the 1st piece
other number: the order of each fragment in an IP packet



```
v Internet Protocol Version 4, Src: 192.168.2.1, Dst: 192.168.3.254
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 44
    Identification: 0x001c (28)
  v 001. .... = Flags: 0x1, More fragments
      0... .... = Reserved bit: Not set
      .0.. .... = Don't fragment: Not set
      ..1. .... = More fragments: Set
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 255
    Protocol: ICMP (1)
    Header Checksum: 0x1465 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.2.1
    Destination Address: 192.168.3.254
    [Reassembled IPv4 in frame: 3]
v Data (24 bytes)
    Data: 080075d9d0ab01007e38080000000000000001020304
    [Length: 24]
```



```
Internet Protocol Version 4, Src: 192.168.2.1, Dst: 192.168.3.254
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
  Total Length: 44
  Identification: 0x001c (28)
v 001. .... = Flags: 0x1, More fragments
    0... .... = Reserved bit: Not set
    .0.. .... = Don't fragment: Not set
    ..1. .... = More fragments: Set
  ...0 0000 0000 0011 = Fragment Offset: 24
  Time to Live: 255
  Protocol: ICMP (1)
  Header Checksum: 0x1462 [validation disabled]
  [Header checksum status: Unverified]
  Source Address: 192.168.2.1
  Destination Address: 192.168.3.254
  [Reassembled IPv4 in frame: 3]
Data (24 bytes)
  Data: 08090a0b0c0d0e0f101112131415161718191a1b1c1d1
  [Length: 24]
```



```
Internet Protocol Version 4, Src: 192.168.2.1, Dst: 192.168.3.254
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
  Total Length: 36
  Identification: 0x001c (28)
v 000. .... = Flags: 0x0
    0... .... = Reserved bit: Not set
    .0.. .... = Don't fragment: Not set
    ..0. .... = More fragments: Not set
  ...0 0000 0000 0110 = Fragment Offset: 48
```

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Part B. ICMP

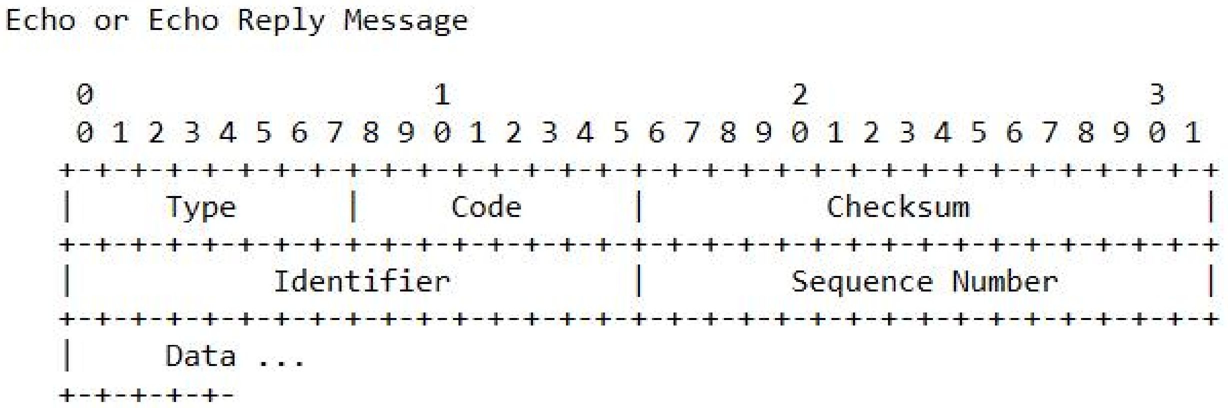
- ICMP is used from gateways to hosts and between hosts to report errors and make routing suggestions.

- ICMP and IP :
  - Internet protocol errors may be reported via the ICMP messages
  - ICMP uses the basic support of IP as if it were a higher level protocol, however, ICMP is actually an integral part of IP, and must be implemented by every IP module.

https://tools.ietf.org/html/rfc792

ICMP (Echo and Echo Reply)

- The data received in the echo message must be returned in the echo reply message.
- Type
  - **8** for **echo request** message;
  - **0** for **echo reply** message.
- Code
  - 0
- The identifier and sequence number may be used by the echo sender to aid in matching the replies with the echo requests. The echoer returns these same values in the echo reply.

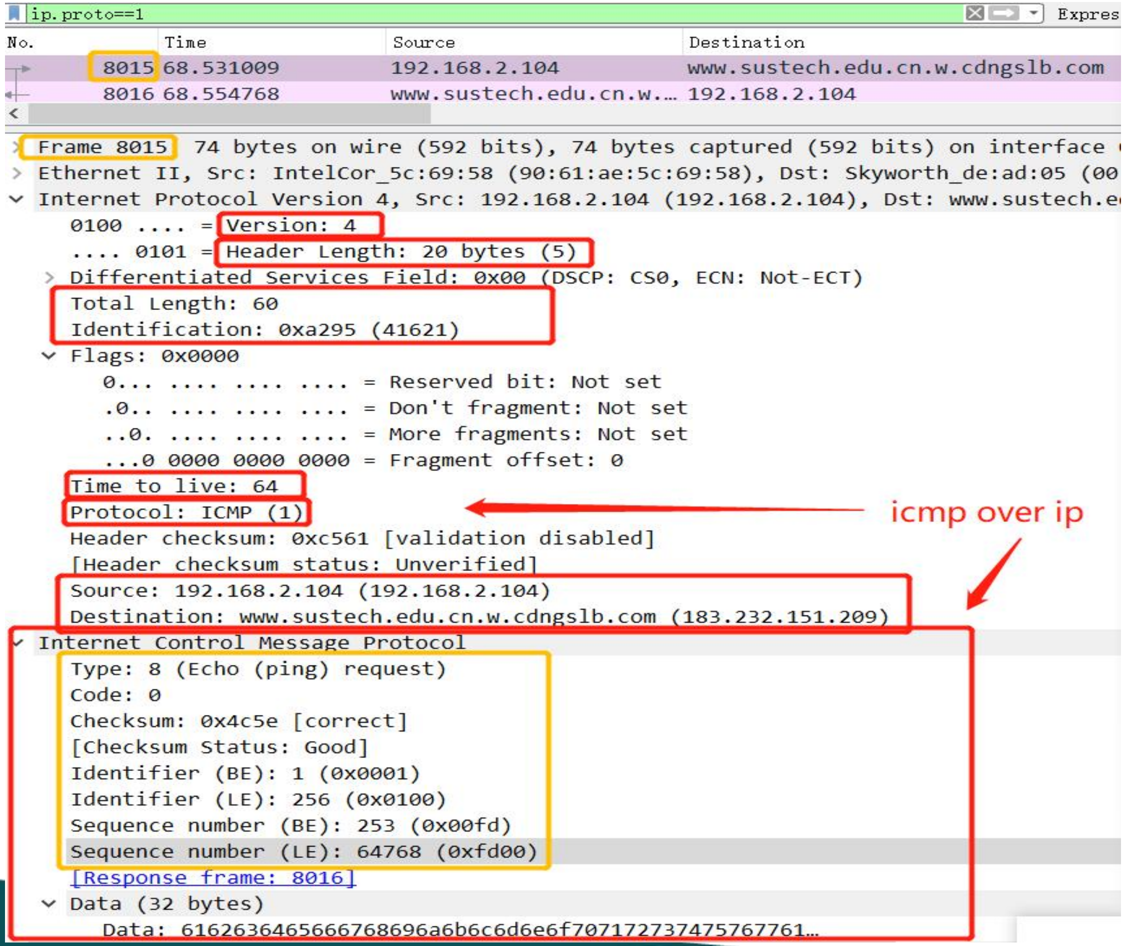


```
Echo or Echo Reply Message

    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |     Code      |          Checksum             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           Identifier          |        Sequence Number        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Data ...
   +-+-+-+-+-
```

ICMP Echo Request

Initial the session with following cmd command: ping www.sustech.edu.cn



```
ip.proto==1                                                       Expres
No.          Time         Source                     Destination
      8015 68.531009    192.168.2.104              www.sustech.edu.cn.w.cdngslb.com
      8016 68.554768    www.sustech.edu.cn.w.…     192.168.2.104
<
> Frame 8015  74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface
> Ethernet II, Src: IntelCor_5c:69:58 (90:61:ae:5c:69:58), Dst: Skyworth_de:ad:05 (00
v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: www.sustech.e
     0100 .... = Version: 4
     .... 0101 = Header Length: 20 bytes (5)
   > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
     Total Length: 60
     Identification: 0xa295 (41621)
   v Flags: 0x0000
        0... .... .... .... = Reserved bit: Not set
        .0.. .... .... .... = Don't fragment: Not set
        ..0. .... .... .... = More fragments: Not set
        ...0 0000 0000 0000 = Fragment offset: 0
     Time to live: 64
     Protocol: ICMP (1)
     Header checksum: 0xc561 [validation disabled]
     [Header checksum status: Unverified]
     Source: 192.168.2.104 (192.168.2.104)
     Destination: www.sustech.edu.cn.w.cdngslb.com (183.232.151.209)
v Internet Control Message Protocol
     Type: 8 (Echo (ping) request)
     Code: 0
     Checksum: 0x4c5e [correct]
     [Checksum Status: Good]
     Identifier (BE): 1 (0x0001)
     Identifier (LE): 256 (0x0100)
     Sequence number (BE): 253 (0x00fd)
     Sequence number (LE): 64768 (0xfd00)
     [Response frame: 8016]
   v Data (32 bytes)
        Data: 6162636465666768696a6b6c6d6e6f7071727374757677 61…
```

icmp over ip

ICMP. type : 8

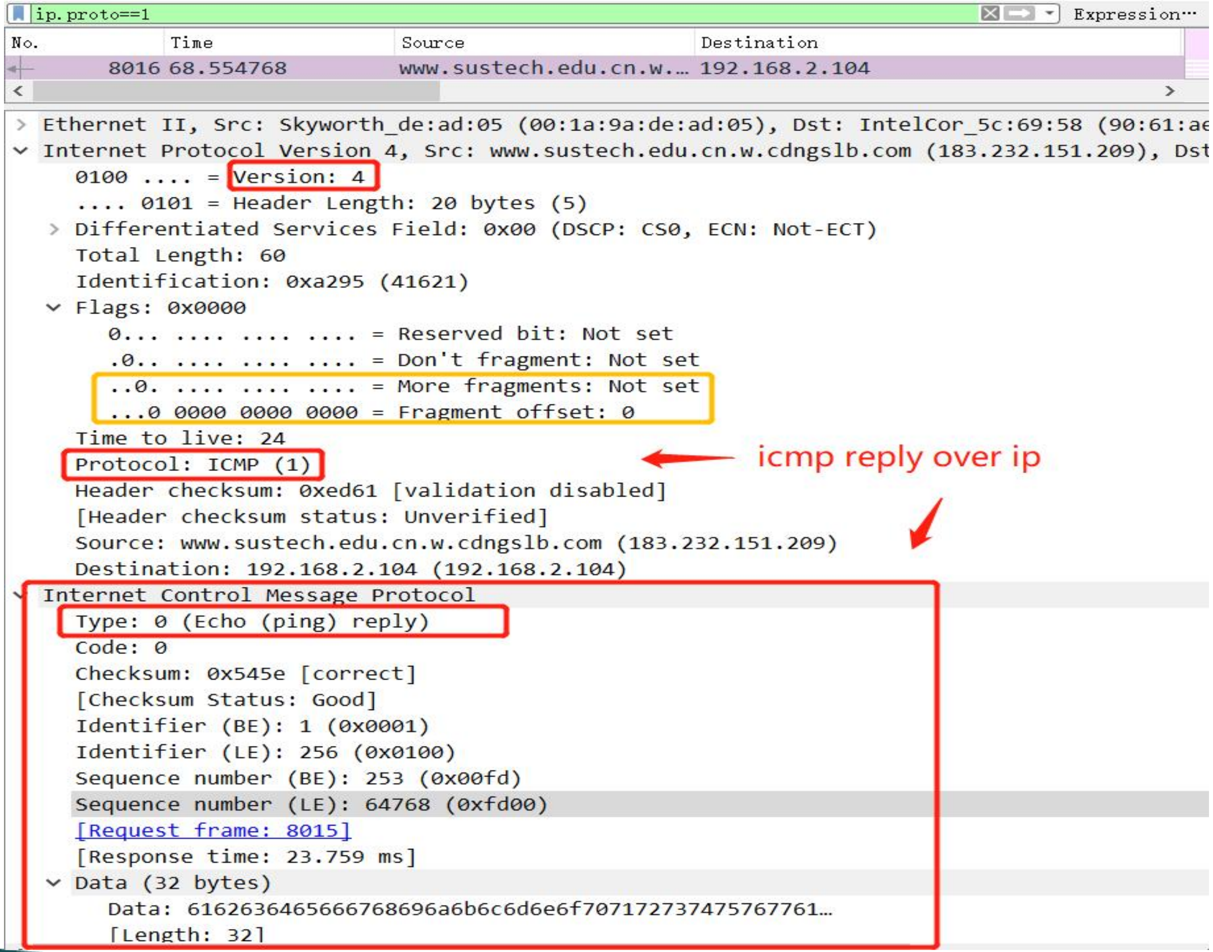
ICMP. code : 0

Tips in Wireshark :
ip.proto == 1 or
ICMP.type

Q1. What's the size of this ICMP Header, ICMP message and this IP packet?

Q2. What's value of Identifier and Sequence number field in this ICMP message?

ICMP Echo Reply



```
ip.proto==1                                                    Expression…
No.        Time          Source                    Destination
     8016 68.554768     www.sustech.edu.cn.w.…    192.168.2.104

> Ethernet II, Src: Skyworth_de:ad:05 (00:1a:9a:de:ad:05), Dst: IntelCor_5c:69:58 (90:61:ae
v Internet Protocol Version 4, Src: www.sustech.edu.cn.w.cdngslb.com (183.232.151.209), Dst
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 60
    Identification: 0xa295 (41621)
  v Flags: 0x0000
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..0. .... .... .... = More fragments: Not set
      ...0 0000 0000 0000 = Fragment offset: 0
    Time to live: 24
    Protocol: ICMP (1)
    Header checksum: 0xed61 [validation disabled]
    [Header checksum status: Unverified]
    Source: www.sustech.edu.cn.w.cdngslb.com (183.232.151.209)
    Destination: 192.168.2.104 (192.168.2.104)
v Internet Control Message Protocol
    Type: 0 (Echo (ping) reply)
    Code: 0
    Checksum: 0x545e [correct]
    [Checksum Status: Good]
    Identifier (BE): 1 (0x0001)
    Identifier (LE): 256 (0x0100)
    Sequence number (BE): 253 (0x00fd)
    Sequence number (LE): 64768 (0xfd00)
    [Request frame: 8015]
    [Response time: 23.759 ms]
  v Data (32 bytes)
      Data: 6162636465666768696a6b6c6d6e6f7071727374757677 61…
      [Length: 32]
```

icmp reply over ip

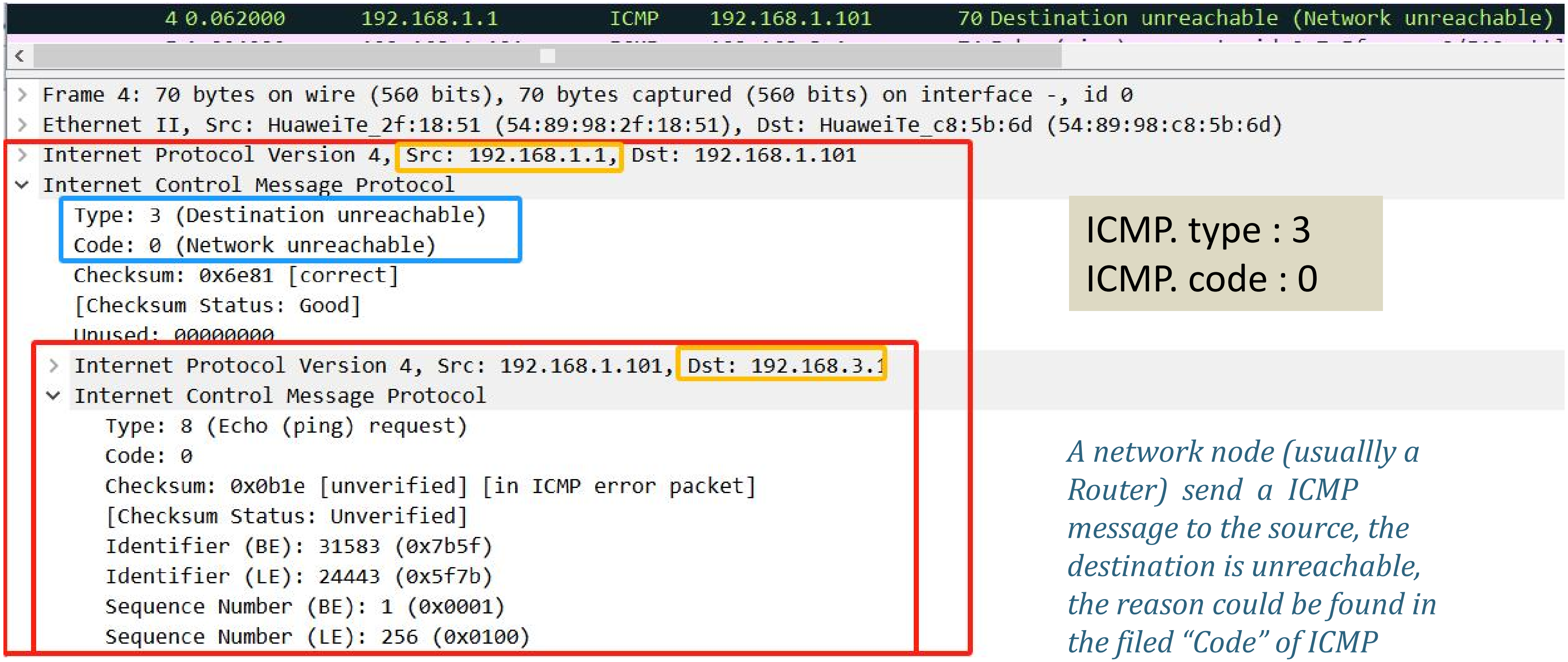
ICMP. type : 0
ICMP. code : 0

Q1. List the differences between the #8015 frame(described on last page) and the #8016 frame(described on this page)

1. soure and destination
2. TTL field of IP Header
3. Total Length field of IP Headeer
4. ICMP Header
…

Tips in Wireshark : ICMP.type

ICMP Destination unreachable(1)



```
4 0.062000    192.168.1.1    ICMP    192.168.1.101    70 Destination unreachable (Network unreachable)

> Frame 4: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface -, id 0
> Ethernet II, Src: HuaweiTe_2f:18:51 (54:89:98:2f:18:51), Dst: HuaweiTe_c8:5b:6d (54:89:98:c8:5b:6d)
> Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.101
v Internet Control Message Protocol
    Type: 3 (Destination unreachable)
    Code: 0 (Network unreachable)
    Checksum: 0x6e81 [correct]
    [Checksum Status: Good]
    Unused: 00000000
  > Internet Protocol Version 4, Src: 192.168.1.101, Dst: 192.168.3.1
  v Internet Control Message Protocol
      Type: 8 (Echo (ping) request)
      Code: 0
      Checksum: 0x0b1e [unverified] [in ICMP error packet]
      [Checksum Status: Unverified]
      Identifier (BE): 31583 (0x7b5f)
      Identifier (LE): 24443 (0x5f7b)
      Sequence Number (BE): 1 (0x0001)
      Sequence Number (LE): 256 (0x0100)
```

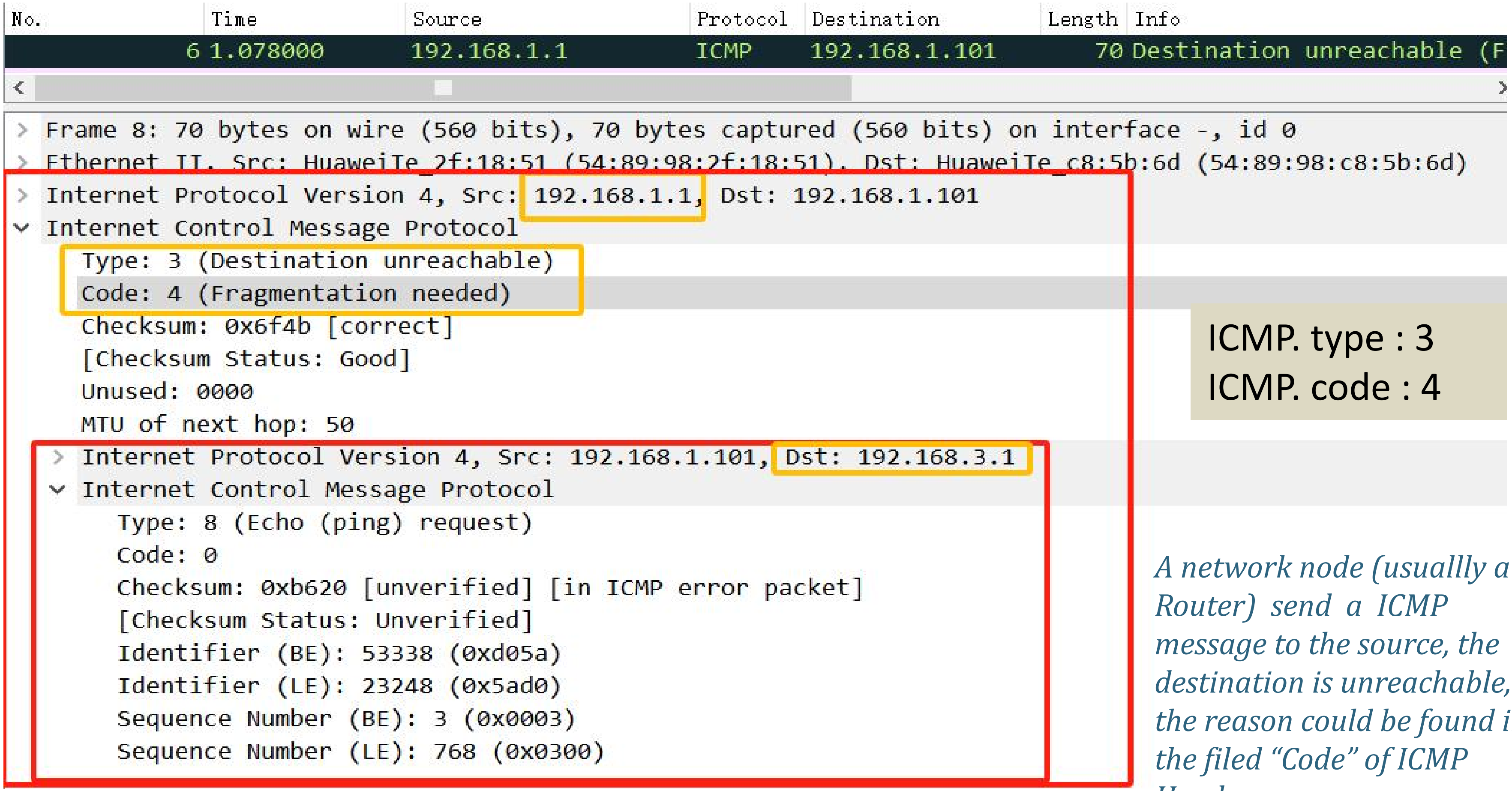
ICMP. type : 3

ICMP. code : 0

A network node (usuallly a Router) send a ICMP message to the source, the destination is unreachable, the reason could be found in the filed “Code” of ICMP Header.

Tips in Wireshark : ICMP.type

ICMP Destination unreachable(2)



```
No.          Time          Source            Protocol  Destination       Length  Info
           6 1.078000      192.168.1.1       ICMP      192.168.1.101         70  Destination unreachable (F
```

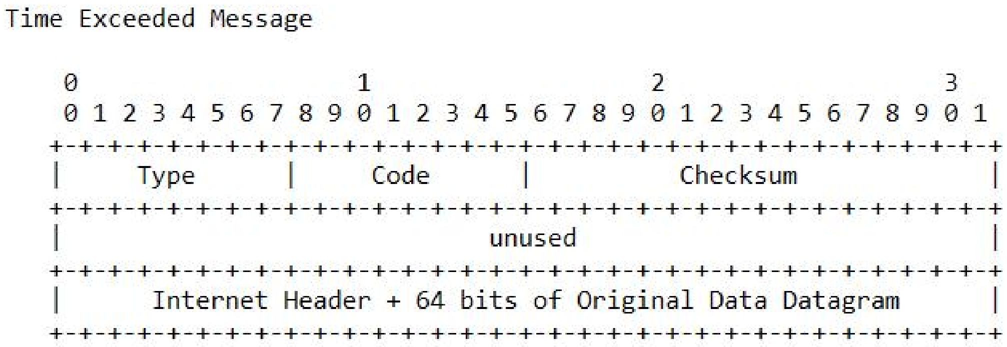
```
> Frame 8: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface -, id 0
> Ethernet II, Src: HuaweiTe_2f:18:51 (54:89:98:2f:18:51), Dst: HuaweiTe_c8:5b:6d (54:89:98:c8:5b:6d)
> Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.101
v Internet Control Message Protocol
    Type: 3 (Destination unreachable)
    Code: 4 (Fragmentation needed)
    Checksum: 0x6f4b [correct]
    [Checksum Status: Good]
    Unused: 0000
    MTU of next hop: 50
  > Internet Protocol Version 4, Src: 192.168.1.101, Dst: 192.168.3.1
  v Internet Control Message Protocol
      Type: 8 (Echo (ping) request)
      Code: 0
      Checksum: 0xb620 [unverified] [in ICMP error packet]
      [Checksum Status: Unverified]
      Identifier (BE): 53338 (0xd05a)
      Identifier (LE): 23248 (0x5ad0)
      Sequence Number (BE): 3 (0x0003)
      Sequence Number (LE): 768 (0x0300)
```

ICMP. type : 3
ICMP. code : 4

A network node (usuallly a Router) send a ICMP message to the source, the destination is unreachable, the reason could be found in the filed “Code” of ICMP Header.

Tips in Wireshark : ICMP.type

ICMP： Time Exceeded(1)



```
Time Exceeded Message

    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |     Code      |          Checksum             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             unused                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Internet Header + 64 bits of Original Data Datagram      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type： 11

Code 0 = time to live exceeded in transit;
Code 1 = fragment reassembly time exceeded.

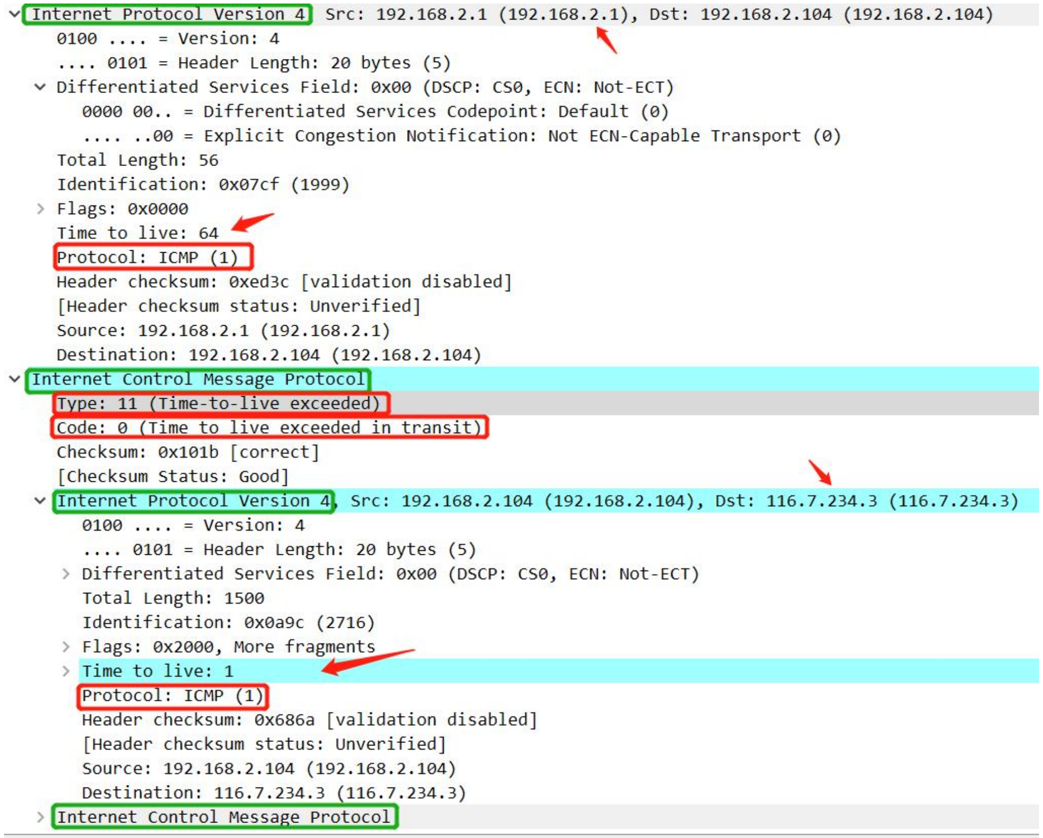
If the gateway processing a datagram finds the time to live field is zero it must discard the datagram. The gateway may also notify the source host via the time exceeded message.

If a host reassembling a fragmented datagram cannot complete the reassembly due to missing fragments within its time limit it discards the datagram, and it may send a time exceeded message.

Code 0 may be received from a gateway. Code 1 may be received from a host.

ICMP： Time Exceeded(2)

Initial the session with following cmd: tracert / traceroute



```
v Internet Protocol Version 4, Src: 192.168.2.1 (192.168.2.1), Dst: 192.168.2.104 (192.168.2.104)
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  v Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      0000 00.. = Differentiated Services Codepoint: Default (0)
      .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 56
    Identification: 0x07cf (1999)
  > Flags: 0x0000
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0xed3c [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.1 (192.168.2.1)
    Destination: 192.168.2.104 (192.168.2.104)
v Internet Control Message Protocol
    Type: 11 (Time-to-live exceeded)
    Code: 0 (Time to live exceeded in transit)
    Checksum: 0x101b [correct]
    [Checksum Status: Good]
  v Internet Protocol Version 4, Src: 192.168.2.104 (192.168.2.104), Dst: 116.7.234.3 (116.7.234.3)
      0100 .... = Version: 4
      .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      Total Length: 1500
      Identification: 0x0a9c (2716)
    > Flags: 0x2000, More fragments
    > Time to live: 1
      Protocol: ICMP (1)
      Header checksum: 0x686a [validation disabled]
      [Header checksum status: Unverified]
      Source: 192.168.2.104 (192.168.2.104)
      Destination: 116.7.234.3 (116.7.234.3)
  > Internet Control Message Protocol
```

Q1. Is the outside IP’s src address same with the inside IP’s dest address? Why?

Q2. Is the TTL of outside IP same with which in inside IP? why?

Tips in Wireshark : *ICMP.type*

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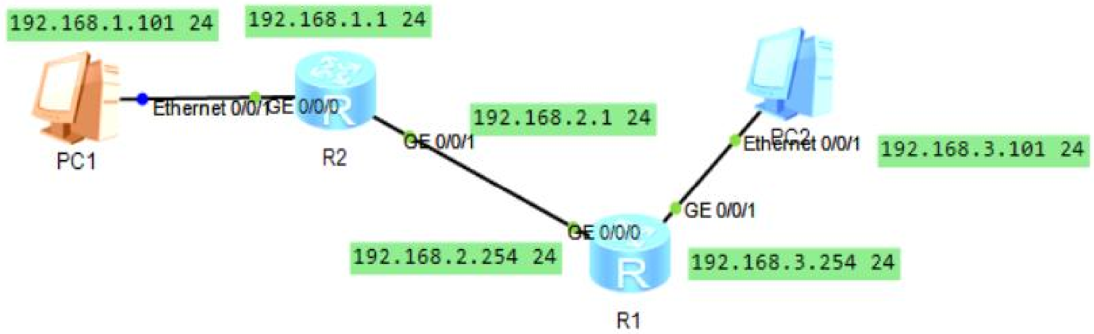
Demo2-ICMP Time Exceeded(1)



Build the network as the topology shown on the top.

Do the configuration to make PC1 could send/receive the packet to/from PC2.

Do the capture on the Ethernet 0/0/0 of PC1

Initiate "**tracert**" testing on PC1 to track the route information on the network path from PC1 to PC2.

Answer the following question:

Q1. What's the type of the ICMP message would be received by PC1?

Q2. How does PC1 get the route information on the network path from PC1 to PC2?

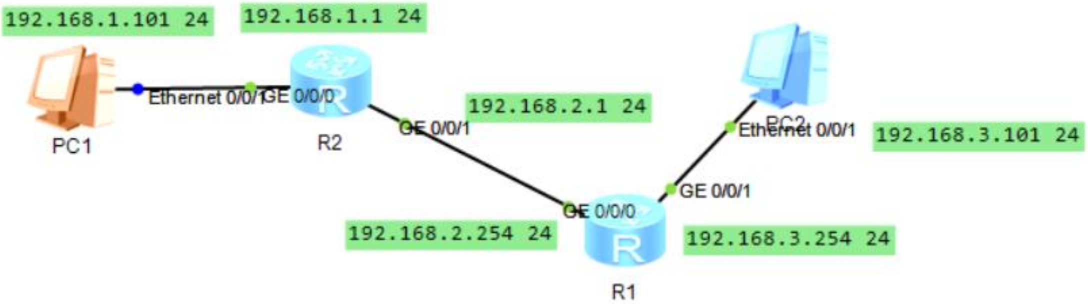
Q3. In this test, Which interfaces on the network path can a PC obtain relevant information from ?

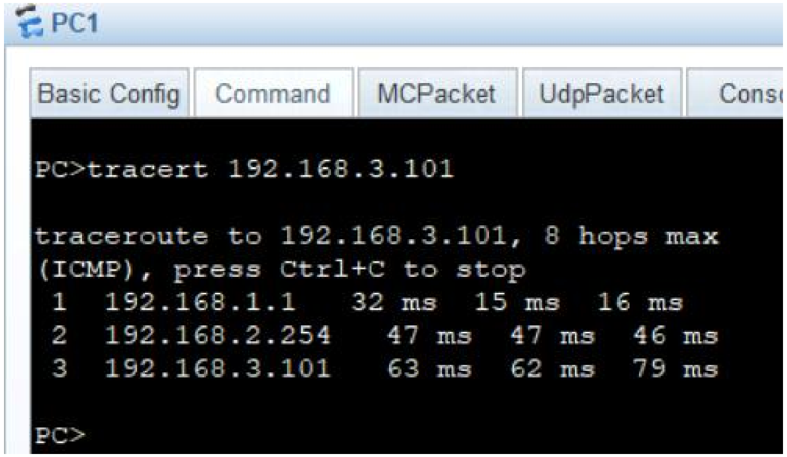
```
PC> tracert 192.168.3.101
1  ?   xxms  xxms  xxms
2  ?   xxms  xxms  xxms
3  ?   xxms  xxms  xxms
```

Demo2- ICMP Time Exceeded(2)

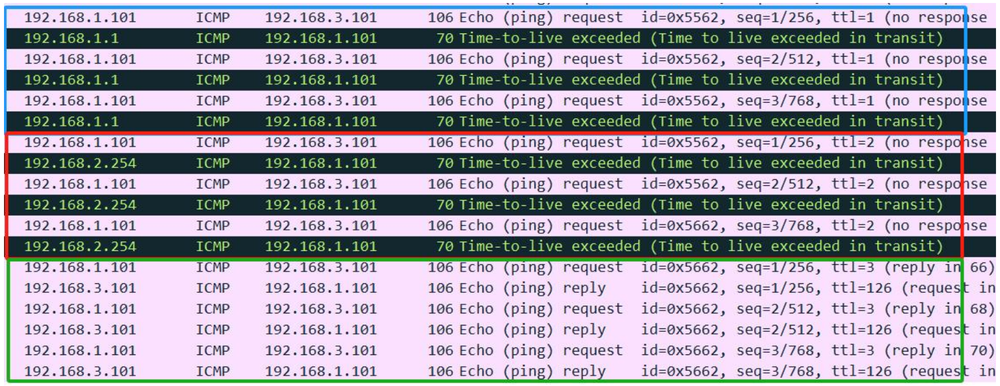
Do the capture on the Ethernet 0/0/0 of PC1

Initiate “**tracert**” testing on PC1 to track the route information on the network path from PC1 to PC2.



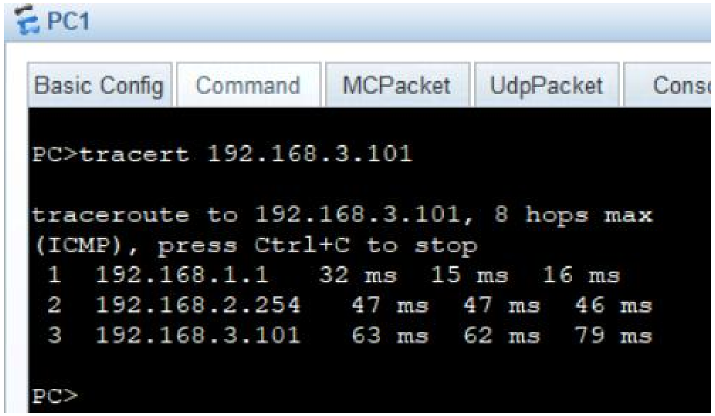


```
PC>tracert 192.168.3.101

traceroute to 192.168.3.101, 8 hops max
(ICMP), press Ctrl+C to stop
 1  192.168.1.1    32 ms   15 ms   16 ms
 2  192.168.2.254    47 ms   47 ms   46 ms
 3  192.168.3.101    63 ms   62 ms   79 ms

PC>
```

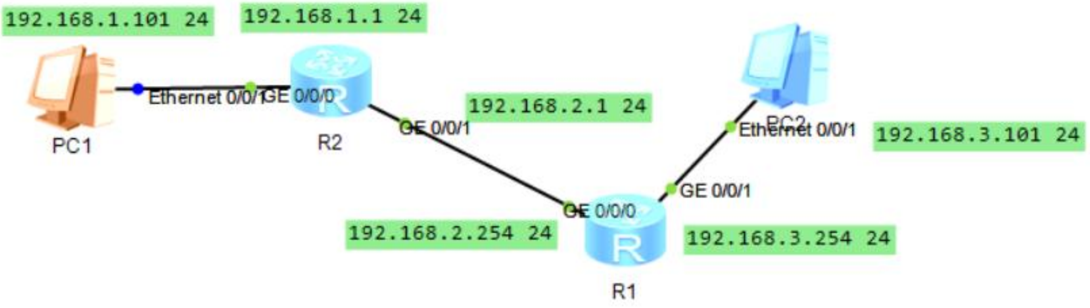


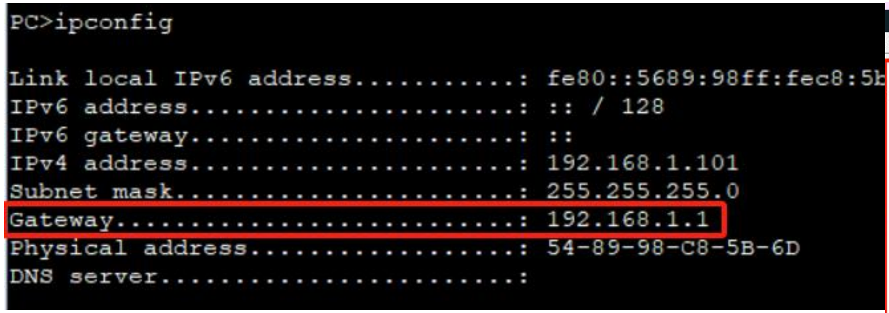
```
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5562, seq=1/256, ttl=1 (no response
192.168.1.1      ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5562, seq=2/512, ttl=1 (no response
192.168.1.1      ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5562, seq=3/768, ttl=1 (no response
192.168.1.1      ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5562, seq=1/256, ttl=2 (no response
192.168.2.254    ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5562, seq=2/512, ttl=2 (no response
192.168.2.254    ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5662, seq=3/768, ttl=2 (no response
192.168.2.254    ICMP    192.168.1.101     70 Time-to-live exceeded (Time to live exceeded in transit)
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5662, seq=1/256, ttl=3 (reply in 66)
192.168.3.101    ICMP    192.168.1.101    106 Echo (ping) reply    id=0x5662, seq=1/256, ttl=126 (request in
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5662, seq=2/512, ttl=3 (reply in 68)
192.168.3.101    ICMP    192.168.1.101    106 Echo (ping) reply    id=0x5662, seq=2/512, ttl=126 (request in
192.168.1.101    ICMP    192.168.3.101    106 Echo (ping) request  id=0x5662, seq=3/768, ttl=3 (reply in 70)
192.168.3.101    ICMP    192.168.1.101    106 Echo (ping) reply    id=0x5662, seq=3/768, ttl=126 (request in
```

Demo2- ICMP Time Exceeded(3)

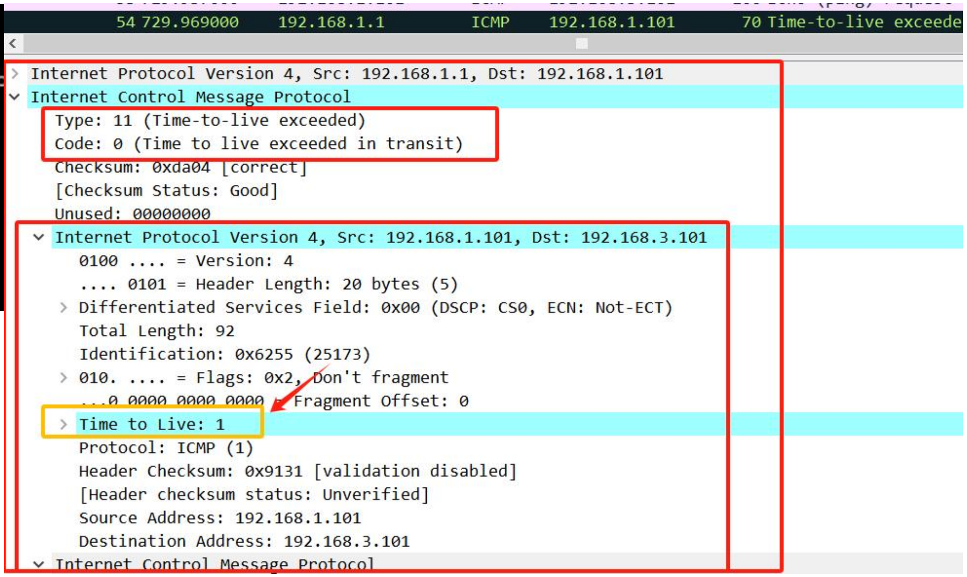


```
PC>tracert 192.168.3.101

traceroute to 192.168.3.101, 8 hops max
(ICMP), press Ctrl+C to stop
 1  192.168.1.1    32 ms  15 ms  16 ms
 2  192.168.2.254   47 ms  47 ms  46 ms
 3  192.168.3.101   63 ms  62 ms  79 ms

PC>
```





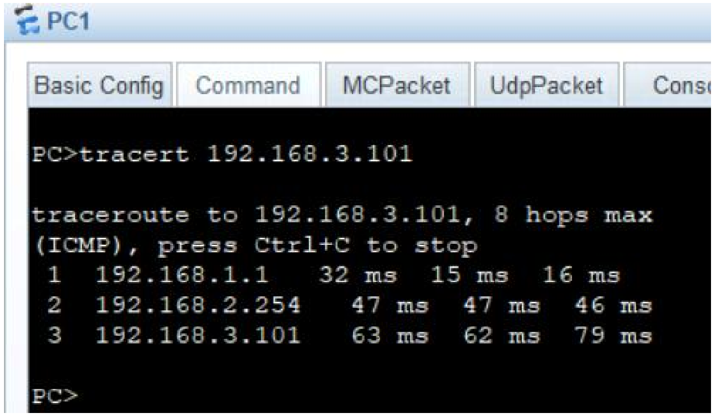
```
PC>ipconfig

Link local IPv6 address...........: fe80::5689:98ff:fec8:5b
IPv6 address......................: :: / 128
IPv6 gateway......................: ::
IPv4 address......................: 192.168.1.101
Subnet mask.......................: 255.255.255.0
Gateway...........................: 192.168.1.1
Physical address..................: 54-89-98-C8-5B-6D
DNS server........................:
```



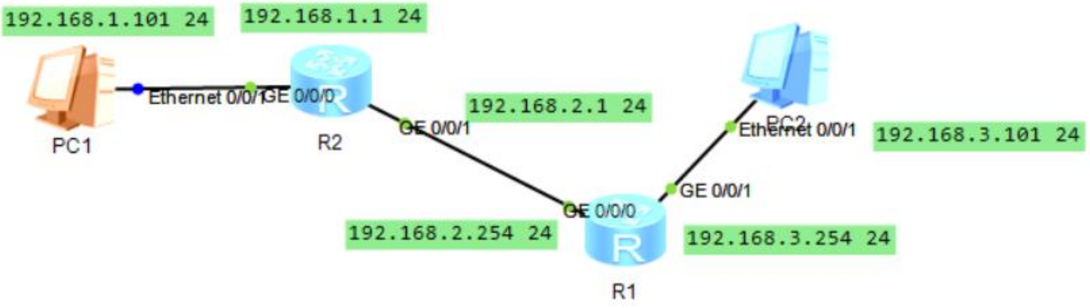
```
     54 729.969000   192.168.1.1      ICMP    192.168.1.101     70 Time-to-live exceede
<
> Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.101
v Internet Control Message Protocol
    Type: 11 (Time-to-live exceeded)
    Code: 0 (Time to live exceeded in transit)
    Checksum: 0xda04 [correct]
    [Checksum Status: Good]
    Unused: 00000000
  v Internet Protocol Version 4, Src: 192.168.1.101, Dst: 192.168.3.101
      0100 .... = Version: 4
      .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      Total Length: 92
      Identification: 0x6255 (25173)
    > 010. .... = Flags: 0x2, Don't fragment
      ...0 0000 0000 0000 = Fragment Offset: 0
    > Time to Live: 1
      Protocol: ICMP (1)
      Header Checksum: 0x9131 [validation disabled]
      [Header checksum status: Unverified]
      Source Address: 192.168.1.101
      Destination Address: 192.168.3.101
  v Internet Control Message Protocol
```

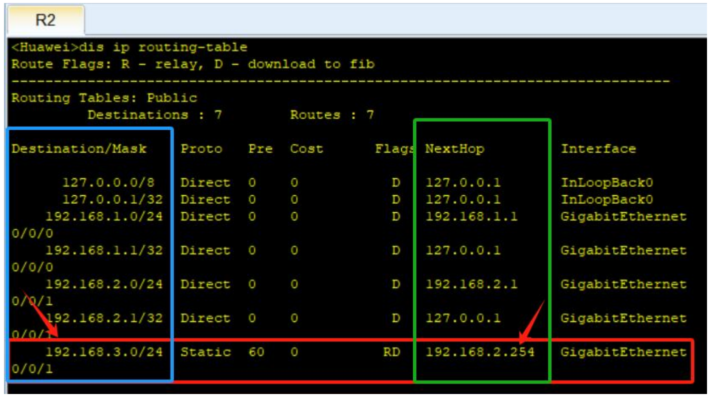
The destination is not in the same subnet as the source, the packet reaches to the 1st "next hop" : gateway.

Demo2- ICMP Time Exceeded(4)



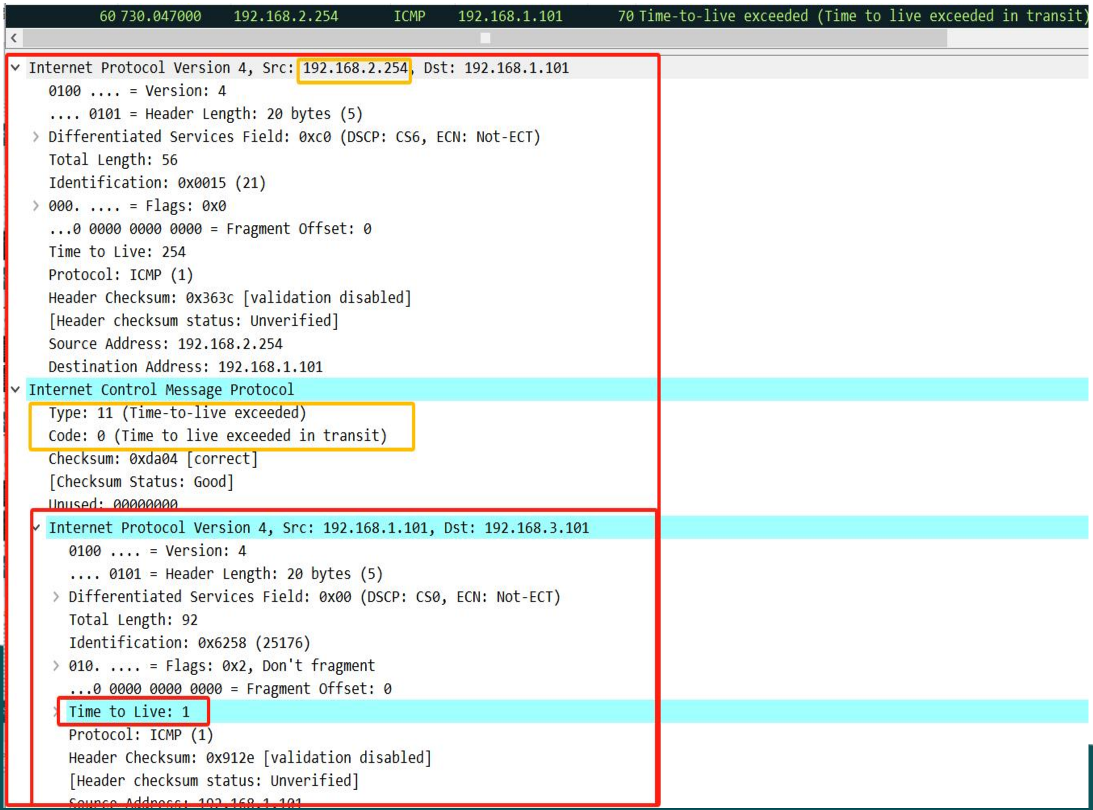
```
PC>tracert 192.168.3.101

traceroute to 192.168.3.101, 8 hops max
(ICMP), press Ctrl+C to stop
 1  192.168.1.1    32 ms  15 ms  16 ms
 2  192.168.2.254   47 ms  47 ms  46 ms
 3  192.168.3.101   63 ms  62 ms  79 ms

PC>
```





```
<Huawei>dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7        Routes : 7

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  Direct  0    0           D   192.168.1.1     GigabitEthernet
0/0/0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.1     GigabitEthernet
0/0/1
    192.168.2.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
    192.168.3.0/24  Static  60   0          RD   192.168.2.254   GigabitEthernet
0/0/1
```

The packet reaches to the 2nd "next hop": 192.168.2.254



```
60 730.047000   192.168.2.254   ICMP   192.168.1.101   70 Time-to-live exceeded (Time to live exceeded in transit)

v Internet Protocol Version 4, Src: 192.168.2.254, Dst: 192.168.1.101
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
    Total Length: 56
    Identification: 0x0015 (21)
  > 000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 254
    Protocol: ICMP (1)
    Header Checksum: 0x363c [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.2.254
    Destination Address: 192.168.1.101
v Internet Control Message Protocol
    Type: 11 (Time-to-live exceeded)
    Code: 0 (Time to live exceeded in transit)
    Checksum: 0xda04 [correct]
    [Checksum Status: Good]
    Unused: 00000000
  v Internet Protocol Version 4, Src: 192.168.1.101, Dst: 192.168.3.101
      0100 .... = Version: 4
      .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      Total Length: 92
      Identification: 0x6258 (25176)
    > 010. .... = Flags: 0x2, Don't fragment
      ...0 0000 0000 0000 = Fragment Offset: 0
      Time to Live: 1
      Protocol: ICMP (1)
      Header Checksum: 0x912e [validation disabled]
      [Header checksum status: Unverified]
      Source Address: 192.168.1.101
```

Part C. IPv6(1)

- **IPv6** is a new version of the Internet Protocol, designed as the successor to IPv4. The changes from IPv4 to IPv6 fall primarily into the following categories:
- **Expanded Addressing Capabilities**: IPv6 increases the IP address size from **32** bits to **128** bits, to support more levels of addressing hierarchy, a much greater number of addressable nodes, and simpler auto-configuration of addresses. The scalability of multicast routing is improved by adding a "scope" field to multicast addresses. And a new type of address called an "anycast address" is defined, used to send a packet to any one of a group of nodes.
- **Header Format Simplification**: Some IPv4 header fields have been dropped or made optional, to reduce the common-case processing cost of packet handling and to limit the bandwidth cost of the IPv6 header.
- **Improved Support for Extensions and Options**: Changes in the way IP header options are encoded allows for more efficient forwarding, less stringent limits on the length of options, and greater flexibility for introducing new options in the future.
- **Flow Labeling Capability**: A new capability is added to enable the labeling of packets belonging to particular traffic "flows" for which the sender requests special handling, such as non-default quality of service or "real-time" service.
- **Authentication and Privacy Capabilities**: Extensions to support authentication, data integrity, and (optional) data confidentiality are specified for IPv6.

https://tools.ietf.org/html/rfc2460

IPv6(2)

- **Version**

  4-bit Internet Protocol version number = 6.
- **Traffic Class**

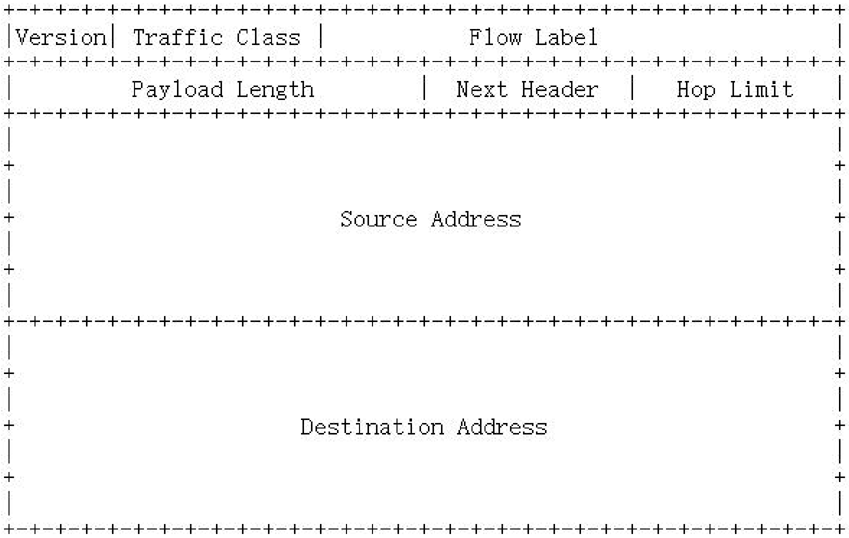
  8-bit traffic class field.
- **Flow Label**

  20-bit flow label.
- **Payload Length**

  16-bit unsigned integer. **Length of the IPv6 payload**, i.e., the rest of the packet following this IPv6 header, in octets. (Note that any extension headers present are considered part of the payload, i.e., included in the length count.)
- **Next Header**

  8-bit selector. Identifies the type of header immediately following the IPv6 header.
- **Hop Limit**

  8-bit unsigned integer. Decremented by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.



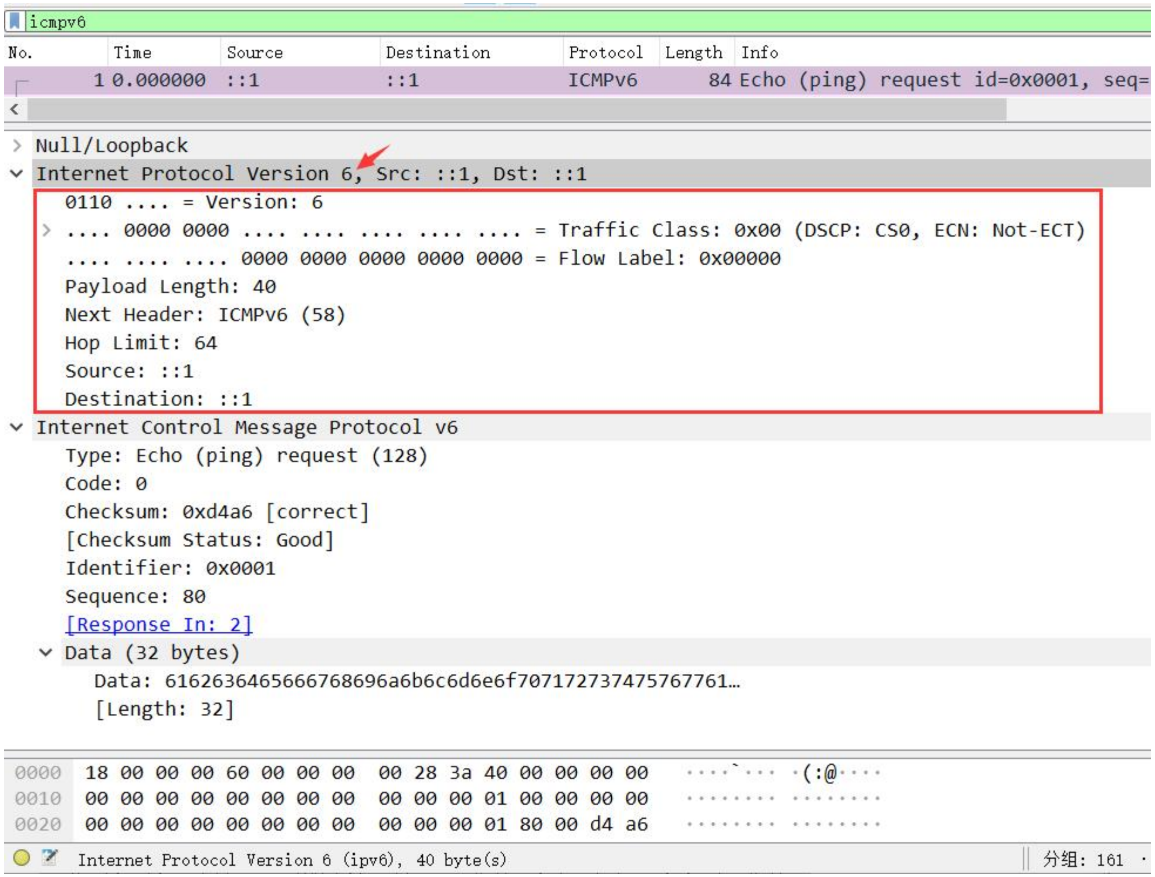
```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version| Traffic Class |           Flow Label                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Payload Length        |  Next Header  |   Hop Limit   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                         Source Address                        +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                      Destination Address                      +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- **Source Address**

  128-bit address of the originator of the packet
- **Destination Address**

  128-bit address of the intended recipient of the packet. (possibly not the ultimate recipient, if a Routing header is present)

IPv6(3)



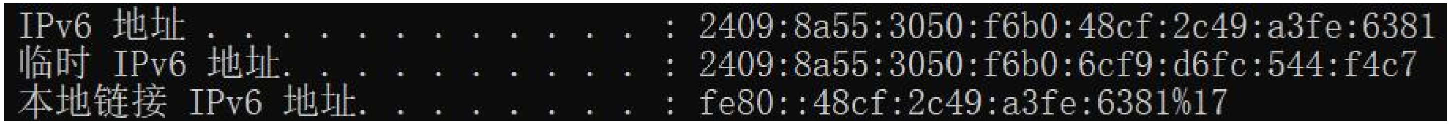
```
icmpv6

No.     Time       Source        Destination     Protocol  Length  Info
      1 0.000000   ::1           ::1             ICMPv6        84 Echo (ping) request id=0x0001, seq=

> Null/Loopback
v Internet Protocol Version 6, Src: ::1, Dst: ::1
    0110 .... = Version: 6
  > .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
    .... .... .... 0000 0000 0000 0000 0000 = Flow Label: 0x00000
    Payload Length: 40
    Next Header: ICMPv6 (58)
    Hop Limit: 64
    Source: ::1
    Destination: ::1
v Internet Control Message Protocol v6
    Type: Echo (ping) request (128)
    Code: 0
    Checksum: 0xd4a6 [correct]
    [Checksum Status: Good]
    Identifier: 0x0001
    Sequence: 80
    [Response In: 2]
  v Data (32 bytes)
      Data: 6162636465666768696a6b6c6d6e6f707172737475767761…
      [Length: 32]

0000  18 00 00 00 60 00 00 00  00 28 3a 40 00 00 00 00   ....`... .(:@....
0010  00 00 00 00 00 00 00 00  00 00 00 01 00 00 00 00   ........ ........
0020  00 00 00 00 00 00 00 00  00 00 00 01 80 00 d4 a6   ........ ........

Internet Protocol Version 6 (ipv6), 40 byte(s)          分组: 161 ·
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version| Traffic Class |           Flow Label                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Payload Length        |  Next Header  |   Hop Limit   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                         Source Address                        +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                      Destination Address                      +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

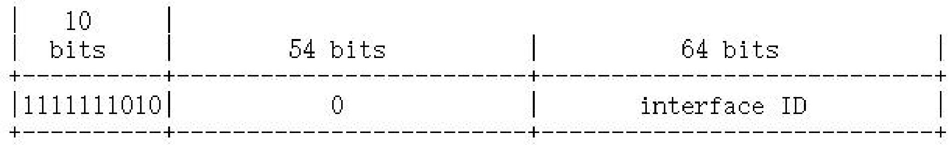
using 'ping -6 localhost' to invoke an ICMPv6 transaction.

IPv6 Address

- Text Representation of Addresses
  - The preferred form is x:x:x:x:x:x:x:x, where the 'x's are the hexadecimal values of the eight 16-bit pieces of the address
  - In order to make writing addresses containing zero bits easier a special syntax is available to compress the zeros. The use of “::” indicates multiple groups of 16-bits of zeros. The "::" can only appear once in an address.
- Address Type Representation
  - The address 0:0:0:0:0:0:0:0 is called the unspecified address.
  - The unicast address 0:0:0:0:0:0:0:1 is called the loopback address.
  - Link-Local Unicast Addresses are designed to be used for addressing on a single link for purposes such as auto-address configuration, neighbor discovery, or when no routers are present.



```
IPv6 地址 . . . . . . . . . . . . : 2409:8a55:3050:f6b0:48cf:2c49:a3fe:6381
临时 IPv6 地址. . . . . . . . . . : 2409:8a55:3050:f6b0:6cf9:d6fc:544:f4c7
本地链接 IPv6 地址. . . . . . . . : fe80::48cf:2c49:a3fe:6381%17
```



```
|    10    |
|   bits   |         54 bits         |          64 bits           |
+----------+-------------------------+----------------------------+
|1111111010|            0            |        interface ID        |
+----------+-------------------------+----------------------------+
```

https://tools.ietf.org/html/rfc2373

Practise 11.1

-l -4

1. Initiates an ICMP session to test if www.example.com is reachable (setting the packet size to 2023B), and capture the packets.

   – How to initiates an ICMP Echo request with 2023B length?

   – Is there any fragmentation on the IP packets, how to find them?

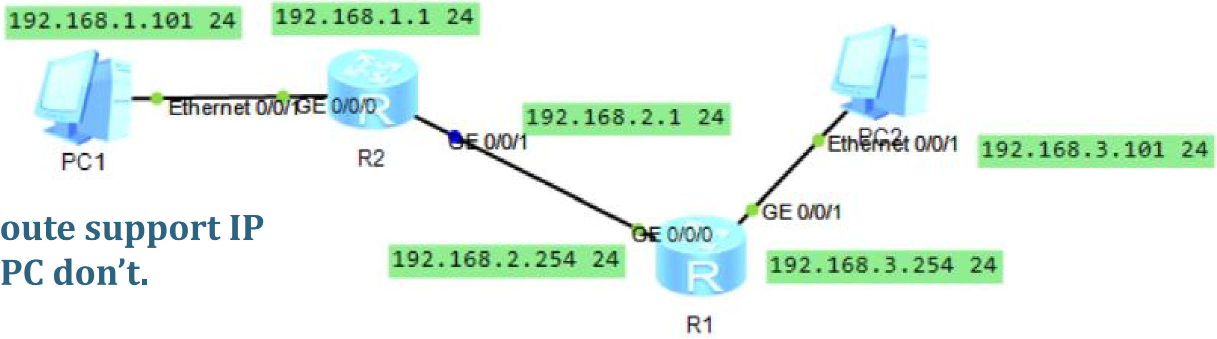
   – How many fragments are the 2023-Byte-length IP packet divided into?

   – How to identify the ICMP Echo request and Echo reply?

   – For the ICMP Echo request, which fragment is the first one, which is the last ? How to identify them?

   – What’s the length of each IP fragment? Is the sum of each fragment’s length equal to the original IP packet ?

Practise 11.2



Tips: in eNSP, route support IP fragment while PC don't.

Build the network as the topology shown on the top.

- 1st, do the configuration to make PC1 could send/receive packet to/from from PC2.
- 2nd, set the the MTU of R2's interface GE0/0/1 as **50**.
- 3rd, do the capture and the "ping" test, answer the following questions:

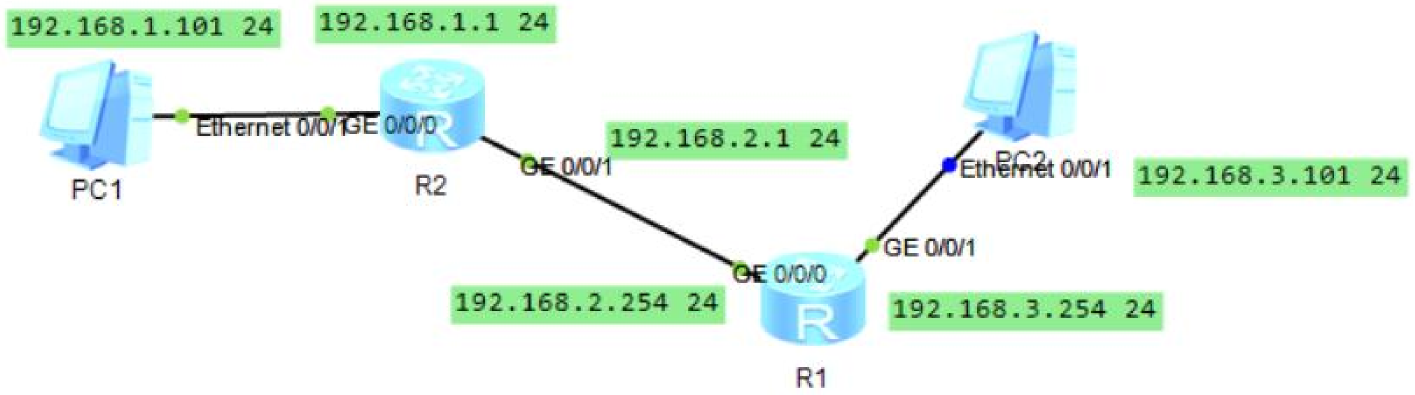
Invoke "ping" test on PC1 to test if PC2 is reachable:

- Could PC1 received the ICMP echo reply message from PC2?
- What's the value of "Don't fragment" bit in IP Header of the packet while it is sent by PC1? What' the value of "Total Length" field in IP Header of the packet while it is sent by PC1?
- if R2 received the IP packet with "Don't fragment" bit is set as 1, and the MTU of its interface GE0/0/1 is set as 50, what would R2 do for the IP packet?

Invoke ping test on PC2 to test if PC1 is reachable

- Could PC1 receive the ICMP echo request message from PC2?
- Could PC2 receive the ICMP echo reply message from PC1?
- Expain the reason.

Practise 11.3(1)



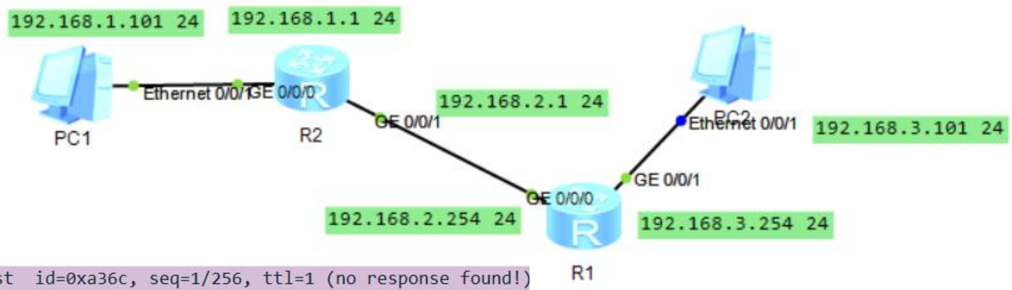
Build the network as the topology shown on the top, do the configuration to make PC1 could send/receive packet to/from PC2.

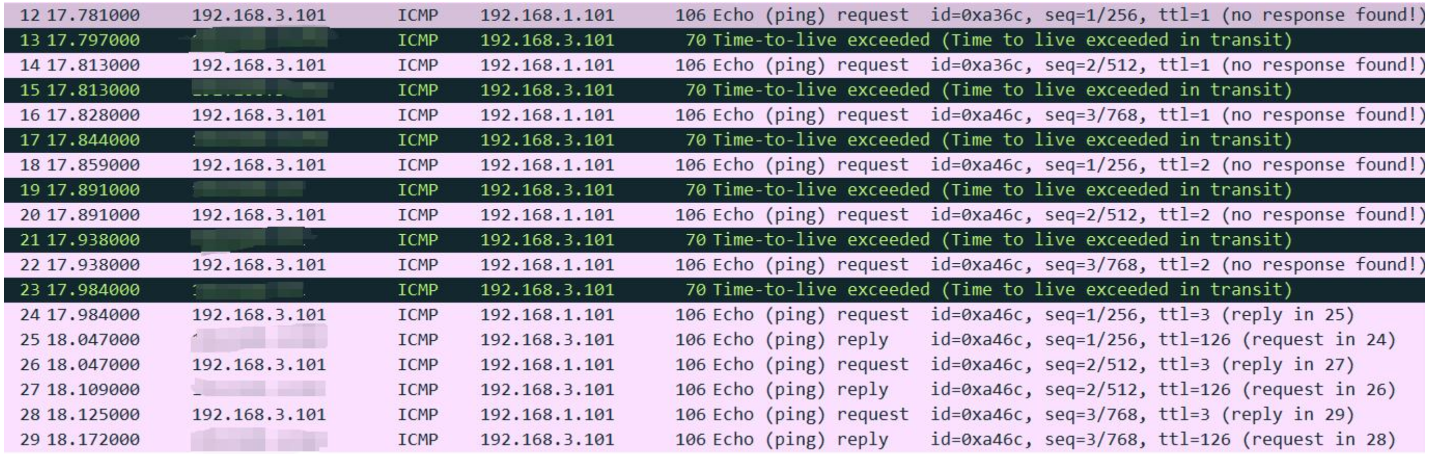
- Use "tracert" to trace the route information from PC2 to PC1, and capture the packets while tracing.
- Please fill in the values of A, B, and C in the table below based on your test, and answer the following questions:

```
PC> tracert 192.168.1.101

 1  A   xxms  xxms  xxms
 2  B   xxms  xxms  xxms
 3  C   xxms  xxms  xxms
?
```

Q1. What's the relationship between the three addresses "A ", "B", and "C" and the following items ?
1) the gateway of PC1
2) the gateway of PC2
3) the next-hop of routing entry on R1 to subnet(192.168.1.0 24)
4) the next-hop of routing entry on R2 to subnet(192.168.3.0 24)

Practise 11.3(2)

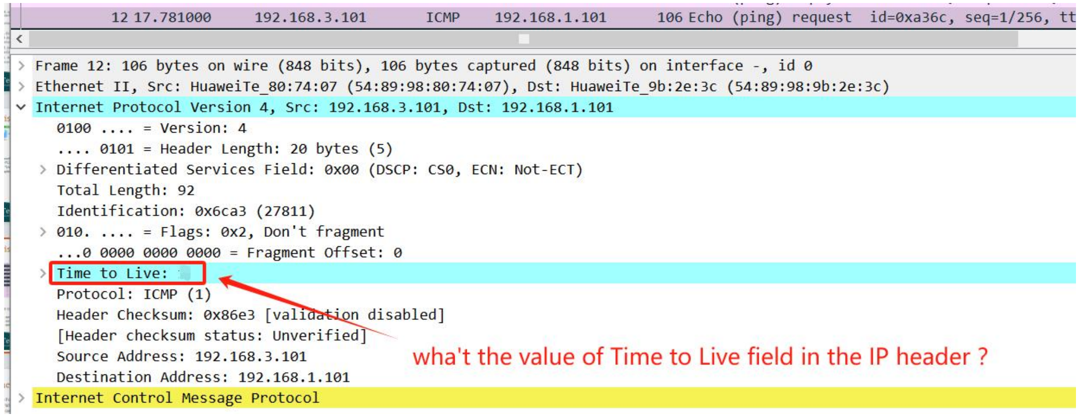




```
12 17.781000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa36c, seq=1/256, ttl=1 (no response found!)
13 17.797000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
14 17.813000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa36c, seq=2/512, ttl=1 (no response found!)
15 17.813000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
16 17.828000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=3/768, ttl=1 (no response found!)
17 17.844000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
18 17.859000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=1/256, ttl=2 (no response found!)
19 17.891000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
20 17.891000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=2/512, ttl=2 (no response found!)
21 17.938000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
22 17.938000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=3/768, ttl=2 (no response found!)
23 17.984000  [redacted]     ICMP  192.168.3.101   70 Time-to-live exceeded (Time to live exceeded in transit)
24 17.984000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=1/256, ttl=3 (reply in 25)
25 18.047000  [redacted]     ICMP  192.168.3.101  106 Echo (ping) reply    id=0xa46c, seq=1/256, ttl=126 (request in 24)
26 18.047000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=2/512, ttl=3 (reply in 27)
27 18.109000  [redacted]     ICMP  192.168.3.101  106 Echo (ping) reply    id=0xa46c, seq=2/512, ttl=126 (request in 26)
28 18.125000  192.168.3.101  ICMP  192.168.1.101  106 Echo (ping) request  id=0xa46c, seq=3/768, ttl=3 (reply in 29)
29 18.172000  [redacted]     ICMP  192.168.3.101  106 Echo (ping) reply    id=0xa46c, seq=3/768, ttl=126 (request in 28)
```

Q2. What is the value of the “TTL” field in the IP header of the following numbered IP packet: 12, 14, 16, 18, 20, 22, 24, 26, 28?

Tips: here #12 is the first ICMP echo request message sent by PC2 during the “tracert” test.



```
12 17.781000   192.168.3.101   ICMP   192.168.1.101   106 Echo (ping) request  id=0xa36c, seq=1/256, tt

> Frame 12: 106 bytes on wire (848 bits), 106 bytes captured (848 bits) on interface -, id 0
> Ethernet II, Src: HuaweiTe_80:74:07 (54:89:98:80:74:07), Dst: HuaweiTe_9b:2e:3c (54:89:98:9b:2e:3c)
v Internet Protocol Version 4, Src: 192.168.3.101, Dst: 192.168.1.101
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 92
    Identification: 0x6ca3 (27811)
  > 010. .... = Flags: 0x2, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
  > Time to Live: [redacted]
    Protocol: ICMP (1)
    Header Checksum: 0x86e3 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.3.101
    Destination Address: 192.168.1.101
> Internet Control Message Protocol
```

what't the value of Time to Live field in the IP header ?