

IP 实验报告

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本次实验所分析的包是由实验文档提供的 <http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip> 的 ip-ethereal-trace-1 包

A look at the captured trace

1. 我（文档）的电脑的 IP 地址是 **192.168.1.102**

1	0.000000	CnetTech_73:8d:ce	Broadcast	ARP	60	Who has 192.168.1.11? Tell 192.168.1.1
2	4.866867	192.168.1.100	192.168.1.1	SSDP	174	M-SEARCH * HTTP/1.1
3	4.868147	192.168.1.100	192.168.1.1	SSDP	175	M-SEARCH * HTTP/1.1
4	5.363536	192.168.1.100	192.168.1.1	SSDP	174	M-SEARCH * HTTP/1.1
5	5.364799	192.168.1.100	192.168.1.1	SSDP	175	M-SEARCH * HTTP/1.1
6	5.864428	192.168.1.100	192.168.1.1	SSDP	174	M-SEARCH * HTTP/1.1
7	5.865461	192.168.1.100	192.168.1.1	SSDP	175	M-SEARCH * HTTP/1.1
8	6.163045	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
9	6.176826	10.216.228.1	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
10	6.188629	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
11	6.202957	24.218.0.153	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
12	6.208597	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
13	6.234505	24.128.190.197	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
14	6.238695	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
15	6.257672	24.128.0.101	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)

> Frame 8: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)

> Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100

> Internet Control Message Protocol

Type: 8 (Echo (ping) request)

Code: 0

Checksum: 0xf7ca [correct]

[Checksum Status: Good]

Identifier (BE): 768 (0x0300)

Identifier (LE): 3 (0x0003)

Sequence Number (BE): 20483 (0x5003)

Sequence Number (LE): 848 (0x0350)

> [No response seen]

> Data (56 bytes)

2. 在 IP 分组的首部中，上层协议是 **ICMP**，且它的值是 **1**。

8	6.163045	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
9	6.176826	10.216.228.1	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
10	6.188629	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
11	6.202957	24.218.0.153	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
12	6.208597	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
13	6.234505	24.128.190.197	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)
14	6.238695	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300
15	6.257672	24.128.0.101	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to live exceeded)

Frame 8: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)

Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100

0100 = Version: 4

.... 0101 = Header Length: 20 bytes (5)

> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)

Total Length: 84

Identification: 0x32d0 (13008)

> Flags: 0x00

...0 0000 0000 0000 = Fragment Offset: 0

> Time to Live: 1

Protocol: ICMP (1)

Header Checksum: 0x2d2c [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.1.102

Destination Address: 128.59.23.100

3. IP 首部一共有 **20** 字节。而有效载荷的字节数为数据报长度减去 IP 首部长度而得，所以为 $84 - 20 = 64$ 字节

8	6.163045	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping)
9	6.176826	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live
10	6.188629	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping)
11	6.202957	24.218.0.153	192.168.1.102	ICMP	70 Time-to-live
12	6.208597	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping)
13	6.234505	24.128.190.197	192.168.1.102	ICMP	70 Time-to-live
14	6.238695	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping)
15	6.257672	24.128.0.101	192.168.1.102	ICMP	70 Time-to-live

Frame 8: 98 bytes on wire (784 bits), 98 bytes captured (784 bits)
 Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:0c:29:1a:73:00)
 Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100

```

0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 84
Identification: 0x32d0 (13008)
> Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
> Time to Live: 1
Protocol: ICMP (1)
Header Checksum: 0x2d2c [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.1.102
Destination Address: 128.59.23.100

```

4. 这个 ip 数据报并没有被分片。因为它的 flags 标志为 0，同时它的偏移量 offset 也为 0，说明该数据报是第一个数据报分片也是最后一个数据报分片。所以它并没有被分片。

8	6.163045	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping) re
9	6.176826	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live e
10	6.188629	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping) re
11	6.202957	24.218.0.153	192.168.1.102	ICMP	70 Time-to-live e
12	6.208597	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping) re
13	6.234505	24.128.190.197	192.168.1.102	ICMP	70 Time-to-live e
14	6.238695	192.168.1.102	128.59.23.100	ICMP	98 Echo (ping) re
15	6.257672	24.128.0.101	192.168.1.102	ICMP	70 Time-to-live e

Frame 8: 98 bytes on wire (784 bits), 98 bytes captured (784 bits)
 Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:0c:29:1a:73:00)
 Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100

```

0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 84
Identification: 0x32d0 (13008)
v Flags: 0x00
  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: 1
Protocol: ICMP (1)
Header Checksum: 0x2d2c [validation disabled]
[Header checksum status: Unverified]

```

5. 从一个数据报到另一个数据报（不考虑同个数据报分片的情况）总是改变的是：**标识 Identification**，**寿命 Time-To-Live**，**首部检验和 Header Checksum**。

No.	Time	Source	Destination	Protocol	Length	Info
368	53.778...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
367	53.777...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
366	53.777...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
365	53.758...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
364	53.757...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
363	53.757...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
361	53.728...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
360	53.727...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
359	53.726...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
358	53.714...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
357	53.714...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
356	53.713...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
355	53.678...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
354	53.677...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
353	53.676...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP
352	53.658...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300, se
351	53.657...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICMP

> Frame 368: 582 bytes on wire (4656 bits), 582 bytes captured (4656 bits)
 > Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)
 > Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 568
 Identification: 0x334a (13130)
 > Flags: 0x01
 ...0 1011 1001 0000 = Fragment Offset: 2960
 Time to Live: 13
 Protocol: ICMP (1)
 Header Checksum: 0x1d5c [validation disabled]
 [Header checksum status: Unverified]

No.	Time	Source	Destination	Protocol	Length	Info
368	53.778...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
367	53.777...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
366	53.777...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
365	53.758...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
364	53.757...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
363	53.757...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
361	53.728...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
360	53.727...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
359	53.726...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
358	53.714...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
357	53.714...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
356	53.713...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
355	53.678...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
354	53.677...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
353	53.676...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=
352	53.658...	192.168.1.102	128.59.23.100	ICMP	582	Echo (ping) request id=0x0300
351	53.657...	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=

> Frame 365: 582 bytes on wire (4656 bits), 582 bytes captured (4656 bits)
 > Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)
 > Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 568
 Identification: 0x3349 (13129)
 > Flags: 0x01
 ...0 1011 1001 0000 = Fragment Offset: 2960
 Time to Live: 12
 Protocol: ICMP (1)
 Header Checksum: 0x1e5d [validation disabled]
 [Header checksum status: Unverified]

6. 这些字段一直保持不变：版本 Version，首部长度 Header Length，源 IP，目的 IP，服务类型 Differentiated Services，上层协议 Protocol。同时这些也都是必须保持不变的。而标识 Identification，寿命 Time-To-Live，首部检验和 Header Checksum 都是必须变的。

这是因为在不同数据报中，标识 Identification 是肯定要变化的，而根据实验需求，我们要通过 Traceroute 确认每个路由器的名字和它的 IP 地址，所以寿命 TTL 肯定也是需要变化的，而这些一旦变化，则首部检验和 Header Checksum 肯定也会变化。同时在进行这个服务的时候，其他字段都是不能变化的。

7. 该模式是 IP 首部中的标识 Identification 字段随着每个 ICMP Echo (ping) 请求而增加（从时间顺序来看）。

361	53.728518	192.168.1.102	128.59.23.100
360	53.727631	192.168.1.102	128.59.23.100
359	53.726969	192.168.1.102	128.59.23.100
358	53.714979	192.168.1.102	128.59.23.100
.... 0101 = Header Length: 20 bytes (5)			
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)			
Total Length: 568			
Identification: 0x3348 (13128)			
> Flags: 0x01			
...0 1011 1001 0000 = Fragment Offset: 2960			
Time to Live: 11			
Protocol: ICMP (1)			
Header Checksum: 0x1f5e [validation disabled]			
[Header checksum status: Unverified]			
Source Address: 192.168.1.102			
365	53.758584	192.168.1.102	128.59.23.100
364	53.757703	192.168.1.102	128.59.23.100
363	53.757036	192.168.1.102	128.59.23.100
361	53.728518	192.168.1.102	128.59.23.100
.... 0101 = Header Length: 20 bytes (5)			
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)			
Total Length: 568			
Identification: 0x3349 (13129)			
> Flags: 0x01			
...0 1011 1001 0000 = Fragment Offset: 2960			
Time to Live: 12			
Protocol: ICMP (1)			
Header Checksum: 0x1e5d [validation disabled]			
[Header checksum status: Unverified]			
Source Address: 192.168.1.102			
368	53.778721	192.168.1.102	128.59.23.100 ICMP
367	53.777832	192.168.1.102	128.59.23.100 IPv4
366	53.777161	192.168.1.102	128.59.23.100 IPv4
365	53.758584	192.168.1.102	128.59.23.100 ICMP
.... 0101 = Header Length: 20 bytes (5)			
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)			
Total Length: 568			
Identification: 0x334a (13130)			
> Flags: 0x01			
...0 1011 1001 0000 = Fragment Offset: 2960			
Time to Live: 13			
Protocol: ICMP (1)			
Header Checksum: 0x1d5c [validation disabled]			
[Header checksum status: Unverified]			
Source Address: 192.168.1.102			

8. 标识 Identification 字段是 **0x9d7c (40316)** , 寿命 TTL 字段是 **255**。

179	38.491817	10.216.228.1	192.168.1.102	ICMP
135	33.470548	10.216.228.1	192.168.1.102	ICMP
94	28.462264	10.216.228.1	192.168.1.102	ICMP
65	16.179649	10.216.228.1	192.168.1.102	ICMP
40	11.174495	10.216.228.1	192.168.1.102	ICMP
9	6.176826	10.216.228.1	192.168.1.102	ICMP
<				
> Frame 9: 70 bytes on wire (560 bits), 70 bytes captured (560 bits)				
> Ethernet II, Src: LinksysG_da:af:73 (00:06:25:da:af:73), Dst: Actiontec				
v Internet Protocol Version 4, Src: 10.216.228.1, Dst: 192.168.1.102				
0100 = Version: 4				
.... 0101 = Header Length: 20 bytes (5)				
> Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)				
Total Length: 56				
Identification: 0x9d7c (40316)				
> Flags: 0x00				
...0 0000 0000 0000 = Fragment Offset: 0				
Time to Live: 255				
Protocol: ICMP (1)				
Header Checksum: 0x6ca0 [validation disabled]				
[Header checksum status: Unverified]				

9. 标识 Identification 是会一直变化的，而寿命 TTL 是会保持不变的。因为标识是一个独一无二的值，而每次返回的 ICMP TTL-exceeded 回复都是一个新的数据报，所以其标识是一直会变化的。而寿命 TTL 是保持不变是因为第一跳返回的 TTL 总是相等的。

```

179 38.491817 10.216.228.1 192.168.1.102
135 33.470548 10.216.228.1 192.168.1.102
94 28.462264 10.216.228.1 192.168.1.102
65 16.179649 10.216.228.1 192.168.1.102
40 11.174495 10.216.228.1 192.168.1.102
9 6.176826 10.216.228.1 192.168.1.102
<
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: 0)
Total Length: 56
Identification: 0x9d7c (40316)
> Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 255
Protocol: ICMP (1)
Header Checksum: 0x6ca0 [validation disabled]
[Header checksum status: Unverified]
Source Address: 10.216.228.1
Destination Address: 192.168.1.102
> Internet Control Message Protocol
179 38.491817 10.216.228.1 192.168.1.102
135 33.470548 10.216.228.1 192.168.1.102
94 28.462264 10.216.228.1 192.168.1.102
65 16.179649 10.216.228.1 192.168.1.102
40 11.174495 10.216.228.1 192.168.1.102
9 6.176826 10.216.228.1 192.168.1.102
<
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: 0)
Total Length: 56
Identification: 0x9d98 (40344)
> Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 255
Protocol: ICMP (1)
Header Checksum: 0x6c84 [validation disabled]
[Header checksum status: Unverified]
Source Address: 10.216.228.1
Destination Address: 192.168.1.102
> Internet Control Message Protocol

```

Fragment

10. 可以看到，在重新发送更大报文之后，数据报被分片了。

No.	Time	Source	Destination	Protocol	Length	Info
85	16.438258	67.99.58.194	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to li
86	16.443310	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300, s
87	16.463382	192.168.1.102	128.59.23.100	ICMP	98	Echo (ping) request id=0x0300, s
88	16.468603	128.59.1.41	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to li
89	16.499919	128.59.23.100	192.168.1.102	ICMP	98	Echo (ping) reply id=0x0300, s
90	22.928093	192.168.1.102	128.119.245.12	SSH	74	Client: Encrypted packet (len=20)
91	22.952738	128.119.245.12	192.168.1.102	TCP	60	22 → 1170 [ACK] Seq=1 Ack=21 win=
92	28.441511	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICM
93	28.442185	192.168.1.102	128.59.23.100	ICMP	562	Echo (ping) request id=0x0300, s
94	28.462264	10.216.228.1	192.168.1.102	ICMP	70	Time-to-live exceeded (Time to li
95	28.470668	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICM
96	28.471338	192.168.1.102	128.59.23.100	ICMP	562	Echo (ping) request id=0x0300, s
97	28.490663	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICM
98	28.491323	192.168.1.102	128.59.23.100	ICMP	562	Echo (ping) request id=0x0300, s
99	28.520729	192.168.1.102	128.59.23.100	IPv4	1514	Fragmented IP protocol (proto=ICM
100	28.521393	192.168.1.102	128.59.23.100	ICMP	562	Echo (ping) request id=0x0300, s

11. 可以看到，首部中的标志 Flags 被置位，其中 More Fragment 被置位为 1，说明数据报已经被分片。而其中的分片偏移量 Fragment Offset 为 0，说明它是第一个分片，而不是最后一个分片。同时如果它是最后一个分片的话，则它的标志位应该为 0，而不是 1。同时从数据报长度 Total Length 可以看出该数据报的长度为 1500 字节。

90	22.928093	192.168.1.102	128.119.245.12	SSH	74 Client: Encrypted packe
91	22.952738	128.119.245.12	192.168.1.102	TCP	60 22 → 1170 [ACK] Seq=1 /
92	28.441511	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol
93	28.442185	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) request ic
94	28.462264	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded
95	28.470668	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol
96	28.471338	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) request ic
97	28.490663	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol


```

> Frame 92: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits)
> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)
✓ Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 1500
    Identification: 0x32f9 (13049)
  ✓ Flags: 0x20, 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: 1
    Protocol: ICMP (1)
    Header Checksum: 0x077b [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.1.102
    Destination Address: 128.59.23.100

```

12. 从 IP 首部中的标志 Flags 可以看出，它**不是**数据报的第一个分片，因为此时它的标志为 0，表示它是最后一个分片，所以没有更多的分片。同时从它的分片偏移量 Fragment Offset 为 1480 也可以看出，它**不是**数据报的第一个分片。

90	22.928093	192.168.1.102	128.119.245.12	SSH	74 Client: Encrypted packe
91	22.952738	128.119.245.12	192.168.1.102	TCP	60 22 → 1170 [ACK] Seq=1 /
92	28.441511	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol
93	28.442185	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) request ic
94	28.462264	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded
95	28.470668	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol
96	28.471338	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) request ic
97	28.490663	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol


```

> Frame 93: 562 bytes on wire (4496 bits), 562 bytes captured (4496 bits)
> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)
✓ Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.59.23.100
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 548
    Identification: 0x32f9 (13049)
  ✓ Flags: 0x00
    0... .... = Reserved bit: Not set
    .0.. .... = Don't fragment: Not set
    ..0. .... = More fragments: Not set
    ...0 0101 1100 1000 = Fragment Offset: 1480
  > Time to Live: 1
    Protocol: ICMP (1)
    Header Checksum: 0x2a7a [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.1.102
    Destination Address: 128.59.23.100

```

13. 两个分片之间的**数据报长度 Total Length**，**标志 Flags**，**首部检验和 Header Checksum** 有改变。

90	22.928093	192.168.1.102	128.119.245.12	SSH	74 Client: Encryp
91	22.952738	128.119.245.12	192.168.1.102	TCP	60 22 → 1170 [ACK
92	28.441511	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP
93	28.442185	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) re
94	28.462264	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live e
95	28.470668	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP
96	28.471338	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) re
97	28.490663	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP

0100	= Version: 4
....	0101	= Header Length: 20 bytes (5)
>	Differentiated Services Field: 0x00	(DSCP: CS0, ECN: Not-ECT)
	Total Length: 1500	
	Identification: 0x32f9	(13049)
✓	Flags: 0x20	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: 1	
	Protocol: ICMP	(1)
	Header Checksum: 0x077b	[validation disabled]
	[Header checksum status: Unverified]	
	Source Address: 192.168.1.102	
	Destination Address: 128.59.23.100	
	[Reassembled IPv4 in frame: 93]	
>	Data (1480 bytes)	

90	22.928093	192.168.1.102	128.119.245.12	SSH	74 Client: Encryp
91	22.952738	128.119.245.12	192.168.1.102	TCP	60 22 → 1170 [ACK
92	28.441511	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP
93	28.442185	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) re
94	28.462264	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live e
95	28.470668	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP
96	28.471338	192.168.1.102	128.59.23.100	ICMP	562 Echo (ping) re
97	28.490663	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP

0100	= Version: 4
....	0101	= Header Length: 20 bytes (5)
>	Differentiated Services Field: 0x00	(DSCP: CS0, ECN: Not-ECT)
	Total Length: 548	
	Identification: 0x32f9	(13049)
✓	Flags: 0x00	
	0... ..	= Reserved bit: Not set
	.0.. ..	= Don't fragment: Not set
	..0.	= More fragments: Not set
	...0 0101 1100 1000	= Fragment Offset: 1480
>	Time to Live: 1	
	Protocol: ICMP	(1)
	Header Checksum: 0x2a7a	[validation disabled]
	[Header checksum status: Unverified]	
	Source Address: 192.168.1.102	
	Destination Address: 128.59.23.100	
>	[2 IPv4 Fragments (2008 bytes): #92(1480), #93(528)]	
>	Internet Control Message Protocol	

14. 会产生 3 个数据报分片。

210	39.098928	216.140.10.30	192.168.1.102	ICMP	70 Time-to-live exceeded (Time to live exceeded in
211	39.164169	67.99.58.194	192.168.1.102	ICMP	70 Time-to-live exceeded (Time to live exceeded in
212	39.227649	128.59.1.41	192.168.1.102	ICMP	70 Time-to-live exceeded (Time to live exceeded in
213	39.314263	128.59.23.100	192.168.1.102	IPv4	1514 Fragmented IP protocol (proto=ICMP 1, off=0, ID
214	39.322566	128.59.23.100	192.168.1.102	ICMP	562 Echo (ping) reply id=0x0300, seq=40195/925,
215	41.038658	192.168.1.102	199.2.53.206	TCP	62 [TCP Retransmission] [TCP Port numbers reused]
216	43.466136	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol (proto=ICMP 1, off=0, ID
217	43.466808	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol (proto=ICMP 1, off=1480,
218	43.467629	192.168.1.102	128.59.23.100	ICMP	582 Echo (ping) request d=0x0300, seq=40451/926,
219	43.485786	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded (Time to live exceeded in
220	43.492284	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP protocol (proto=ICMP 1, off=0, ID

15. 在这些数据报分片中都变化了的是分片偏移量 **Fragment Offset** 和 **首部检验和 Header Checksum**。而前两个分片的数据报长度 **Total Length** 和**更多分片 More Fragment** 都是一样的，分别为 1500 和 1，与最后一个分片的不一样，最后一个分片的是 568 和 0。

215	41.038658	192.168.1.102	199.2.53.206	TCP	62 [TCP Retransmission]
216	43.466136	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
217	43.466808	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
218	43.467629	192.168.1.102	128.59.23.100	ICMP	582 Echo (ping) request
219	43.485786	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded
220	43.492284	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet

> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)

Total Length: 1500

Identification: 0x3323 (13091)

▼ Flags: 0x20, 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: 1

Protocol: ICMP (1)

Header Checksum: 0x0751 [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.1.102

Destination Address: 128.59.23.100

[Reassembled IPv4 in frame: 218]

215	41.038658	192.168.1.102	199.2.53.206	TCP	62 [TCP Retransmission]
216	43.466136	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
217	43.466808	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
218	43.467629	192.168.1.102	128.59.23.100	ICMP	582 Echo (ping) request
219	43.485786	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded
220	43.492284	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet

> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)

Total Length: 1500

Identification: 0x3323 (13091)

▼ Flags: 0x20, More fragments

0... = Reserved bit: Not set

.0.. = Don't fragment: Not set

..1. = More fragments: Set

...0 0101 1100 1000 = Fragment Offset: 1480

> Time to Live: 1

Protocol: ICMP (1)

Header Checksum: 0x0698 [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.1.102

Destination Address: 128.59.23.100

[Reassembled IPv4 in frame: 218]

215	41.038658	192.168.1.102	199.2.53.206	TCP	62 [TCP Retransmission]
216	43.466136	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
217	43.466808	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet
218	43.467629	192.168.1.102	128.59.23.100	ICMP	582 Echo (ping) request
219	43.485786	10.216.228.1	192.168.1.102	ICMP	70 Time-to-live exceeded
220	43.492284	192.168.1.102	128.59.23.100	IPv4	1514 Fragmented IP packet

Total Length: 568

Identification: 0x3323 (13091)

▼ Flags: 0x01

0... = Reserved bit: Not set

.0.. = Don't fragment: Not set

..0. = More fragments: Not set

...0 1011 1001 0000 = Fragment Offset: 2960

> Time to Live: 1

Protocol: ICMP (1)

Header Checksum: 0x2983 [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.1.102

Destination Address: 128.59.23.100

> [3 IPv4 Fragments (3508 bytes): #216(1480), #217(1480), #218(548)]

> Internet Control Message Protocol