计算机网络第七次实验实验报告

舒文炫

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目录

Chapter 1

实验内容

本次实验内容是以太网协议以及 ARP 协议，与前面实验相同，将会了解这些协议的报文格式

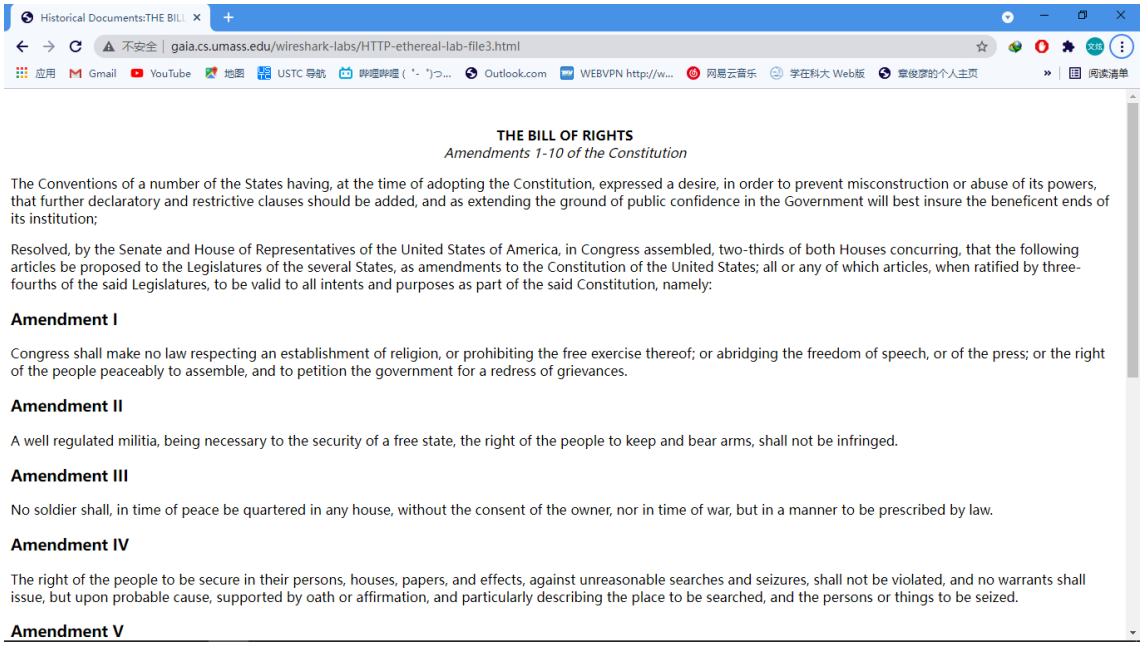
Chapter 2

实验过程

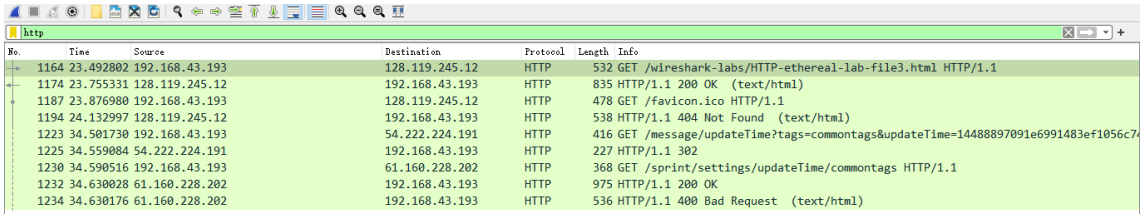
2.1 1. Capturing and analyzing Ethernet frames

2.1.1 过程截图

先清空浏览器的缓存,打开 wireshark,将网址 http://gaia.cs.umass.edu/wireshark-labs/HTTP-ethereal-lab-file3.html 输入浏览器，将打开如下页面

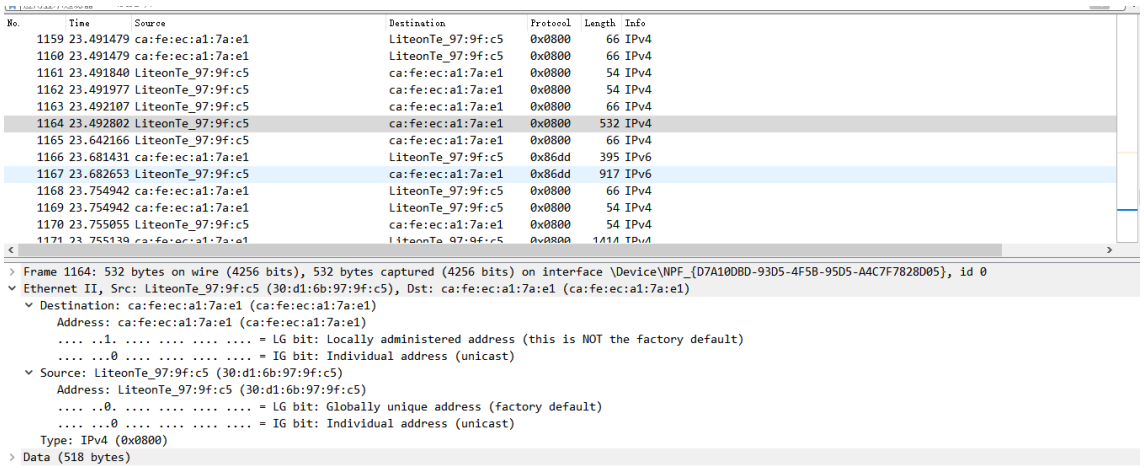


这时停止 wireshark 捕获，要找到 HTTP 的 get 报文，这里我直接设置过滤器为 http，结果如下



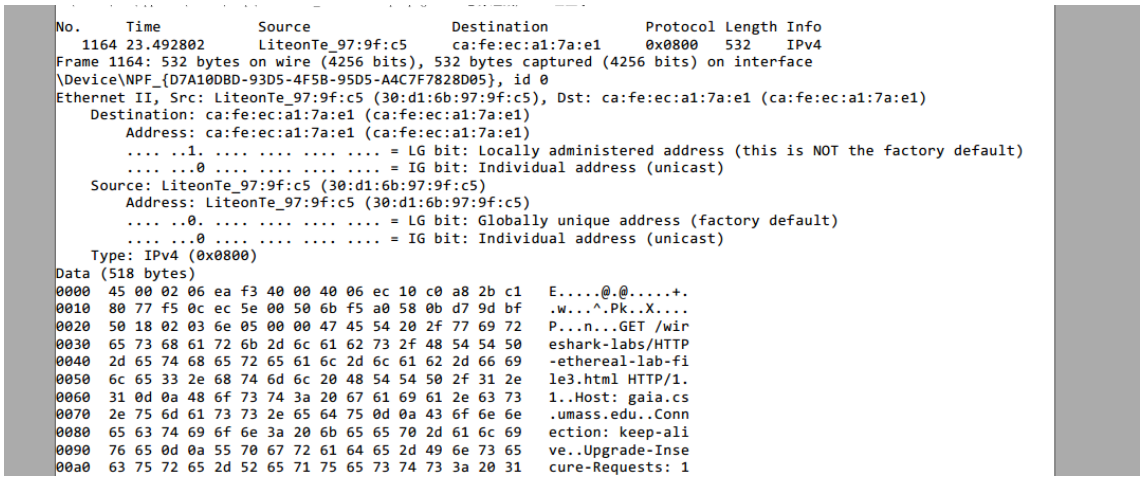
这里第 1164 个包是 HTTP GET 第 1174 个包是 HTTP response，但是实际上这时相应报文的最后一个报文，前面的报文是标记为 TCP 的，这在 TCP 实验里面见过。

然后将 ip 协议去掉，因为这里我们只需要看以太网协议，去掉之后得到下面的截图



2.1.2 小节思考题

这里我们需要的是对应包含 HTTP GET 的报文，我将其打印出来，截图如下



1. What is the 48-bit Ethernet address of your computer?

截图里面有一行，Source: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)，表示我的电脑的以太网地址是 30:d1:6b:97:9f:c5

2. What is the 48-bit destination address in the Ethernet frame? Is this the Ethernet address of gaia.cs.umass.edu? (Hint: the answer is no). What device has this as its Ethernet address? [Note: this is an important question, and one that students sometimes get wrong. Re-read pages 468-469 in the text and make sure you understand the answer here.]

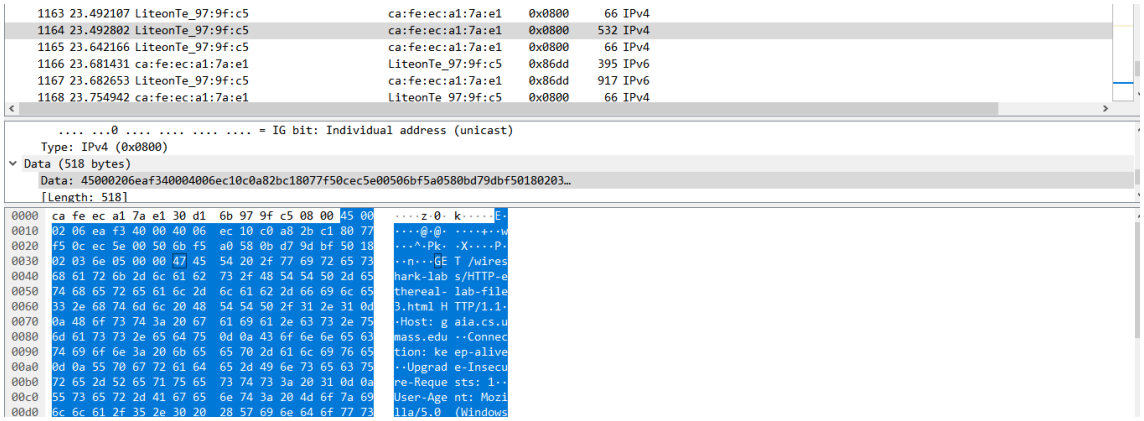
截图里面有一行 Destination: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)，表示目的地址为 ca:fe:ec:a1:7a:e1，这个不是 gaia.cs.umass.edu 的地址，实际上这是通往目的地路径上第一跳路由器接口对应的适配器地址，如果真是 gaia.cs.umass.edu 对应的主机的地址，在这个子网上无法匹配该目的地址，那就没办法发送出去。

3. Give the hexadecimal value for the two-byte Frame type field. What upper layer protocol does this correspond to?

截图里面有一行 Type: IPv4 (0x0800)，值是 0x08000，表示这个上层协议是 ipv4

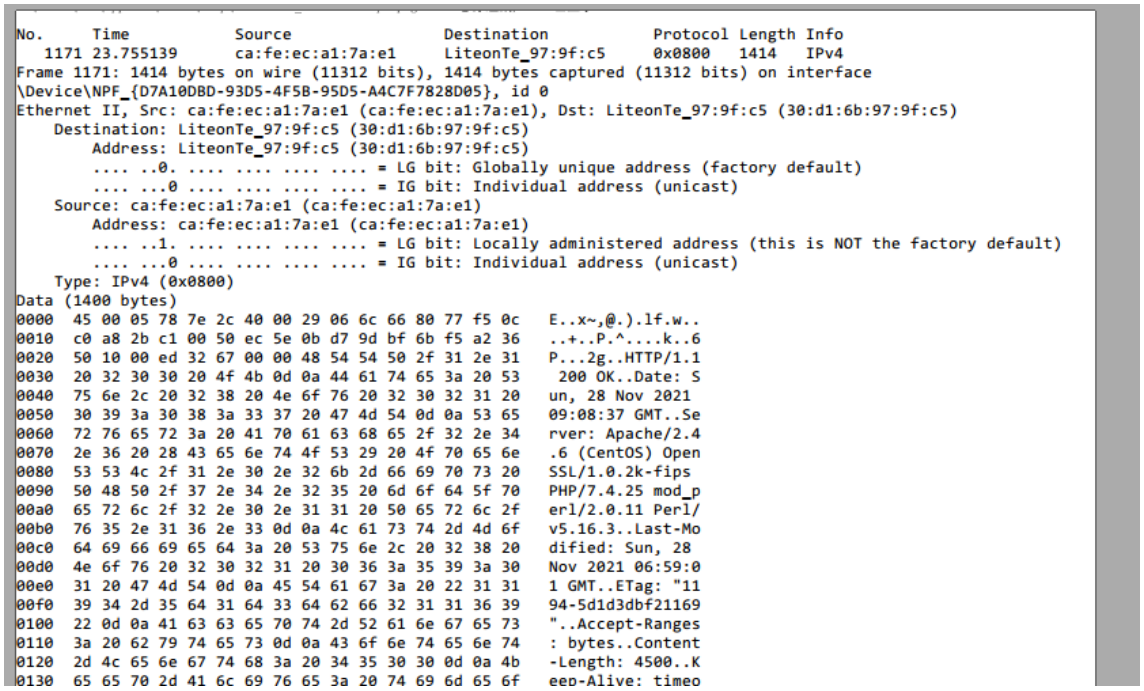
4. How many bytes from the very start of the Ethernet frame does the ASCII “G” in “GET” appear in the Ethernet frame?

我在 data 里面找到了这个 GET，截图如下



选择了 G 这个字母，找到其位置，是第 55 个字节

下面需要 HTTP response 报文，我将其打印出来截图如下



5. What is the value of the Ethernet source address? Is this the address of your computer, or of gaia.cs.umass.edu (Hint: the answer is no). What device has this as its Ethernet address?

截图里面有一行，Source: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)，表示源地址为 ca:fe:ec:a1:7a:e1，这既不是我电脑的地址也不是 gaia.cs.umass.edu 的地址，实际上这是对于我的电脑第一跳路由器接口的地址。

6. What is the destination address in the Ethernet frame? Is this the Ethernet address of your computer?

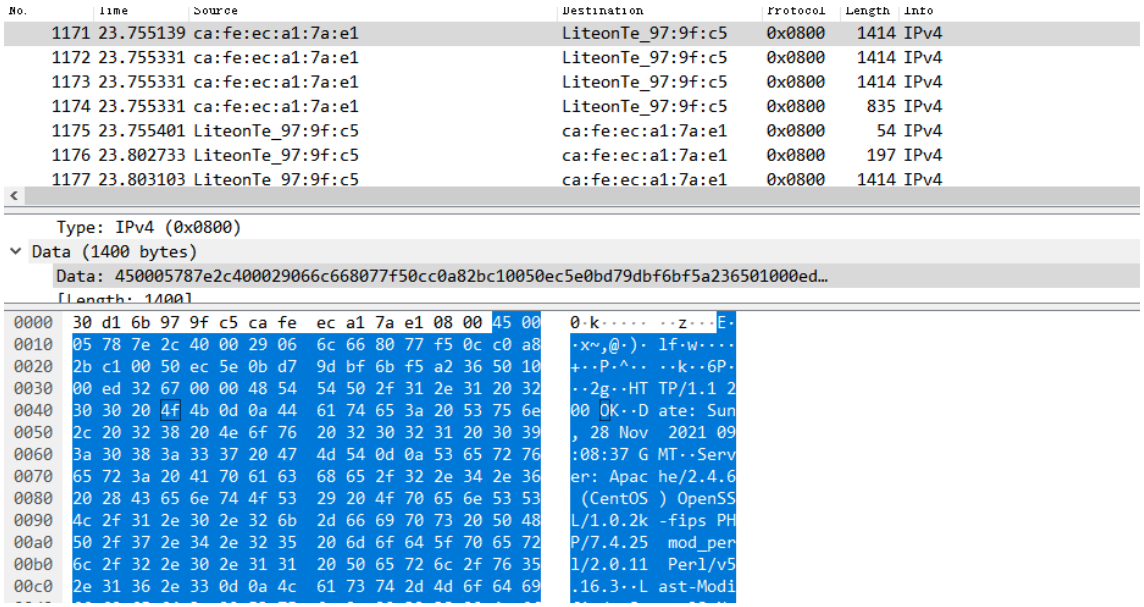
截图里面有一行，Destination: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)，表示目的地址为 30:d1:6b:97:9f:c5，这是我电脑的以太网地址

7. Give the hexadecimal value for the two-byte Frame type field. What upper layer protocol does this correspond to?

截图里面有一行 Type: IPv4 (0x0800)，表示其值为 0x0800，表示上层协议为 ipv4

8. How many bytes from the very start of the Ethernet frame does the ASCII “O” in “OK” (i.e., the HTTP response code) appear in the Ethernet frame?

在 data 里面找到了 OK，选择了 O，截图如下



可以看到这里对应的是第 68 个字节

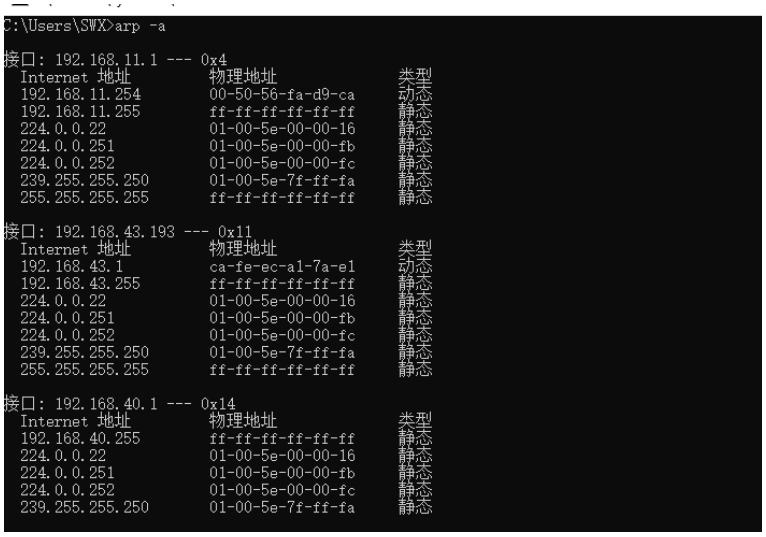
2.2 2. The Address Resolution Protocol

2.2.1 ARP Caching

过程截图

windows 上由 arp 命令可以进行一些 arp 的基本操作，比如表项的查看，增加，删除之类的

运行 arp -a 得到了我这里缓存了一系列 arp 表项



但是运行 arp -d 命令，这个时候需要有管理员权限, 下面是运行 arp -d * 命令的结果

```
C:\windows\system32>arp -d *

C:\windows\system32>arp -a

接口: 192.168.11.1 --- 0x4
  Internet 地址         物理地址              类型
  224.0.0.22            01-00-5e-00-00-16     静态

接口: 192.168.43.193 --- 0x11
  Internet 地址         物理地址              类型
  192.168.43.1          ca-fe-ec-a1-7a-e1     动态
  224.0.0.22            01-00-5e-00-00-16     静态
  255.255.255.255       ff-ff-ff-ff-ff-ff     静态

接口: 192.168.40.1 --- 0x14
  Internet 地址         物理地址              类型
  224.0.0.22            01-00-5e-00-00-16     静态
```

小节思考题

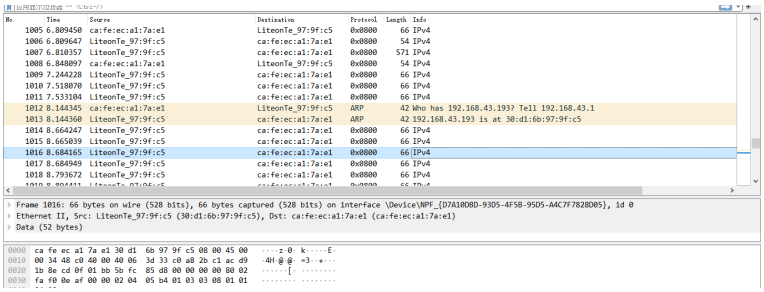
9. Write down the contents of your computer’s ARP cache. What is the meaning of each column value?

上面的截图就是我电脑里面的 arp 缓存，这里第一列为 IP 地址，第二列为其对应的 mac 地址，第三列为类型，分为静态和动态

2.2.2 Observing ARP in action

过程截图

这里首先要清空 arp 缓存，使用 arp -d * 命令，然后清空浏览器缓存，打开 wireshark 开始捕获，在浏览器输入与之前相同的网址，打开页面后，停止捕获，这时我得到了下面的结果



我将需要的 ARP 请求和响应报文打印出来，截图如下, 我这里和实验指导书上面的有些许不同，没有看到广播地址，按照上面流程重试了很多次都是这样，不过不影响做题

这是请求报文

```
No.     Time           Source                Destination           Protocol Length Info
   1012 8.144345       ca:fe:ec:a1:7a:e1     LiteonTe_97:9f:c5     ARP      42     Who has 192.168.43.193? Tell
192.168.43.1
Frame 1012: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface
\Device\NPF_{D7A10DBD-93D5-4F5B-95D5-A4C7F7828D05}, id 0
Ethernet II, Src: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1), Dst: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
    Destination: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
        Address: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Source: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
        Address: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
        .... ..1. .... .... .... .... = LG bit: Locally administered address (this is NOT the factory default)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Type: ARP (0x0806)
Address Resolution Protocol (request)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: request (1)
    Sender MAC address: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
    Sender IP address: 192.168.43.1
    Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Target IP address: 192.168.43.193
```

这是响应报文

```
No.     Time           Source                Destination           Protocol Length Info
   1013 8.144360       LiteonTe_97:9f:c5     ca:fe:ec:a1:7a:e1     ARP      42     192.168.43.193 is at 30:d1:6b:
97:9f:c5
Frame 1013: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface
\Device\NPF_{D7A10DBD-93D5-4F5B-95D5-A4C7F7828D05}, id 0
Ethernet II, Src: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5), Dst: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
    Destination: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
        Address: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
        .... ..1. .... .... .... .... = LG bit: Locally administered address (this is NOT the factory default)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Source: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
        Address: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Type: ARP (0x0806)
Address Resolution Protocol (reply)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: reply (2)
    Sender MAC address: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)
    Sender IP address: 192.168.43.193
    Target MAC address: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
    Target IP address: 192.168.43.1
```

2.2.3 小节思考题

10. What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP request message?

在包含请求报文的帧里面源地址 Source: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)，目的地址 Destination: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)

11. Give the hexadecimal value for the two-byte Ethernet Frame type field. What upper layer protocol does this correspond to?

请求报文截图了有一行 Type: ARP (0x0806)，表示上层协议是 ARP

12.Download the ARP specification from ftp://ftp.rfc-editor.org/in-notes/std/std37.txt. A readable, detailed discussion of ARP is also at http://www.erg.abdn.ac.uk/users/gorry/course/inet-pages/arp.html.
下载的文件如下

std37.txt - 记事本
文件(F) 编辑(E) 格式(O) 查看(V) 帮助(H)

Network Working Group — David C. Plummer
Request For Comments: 826 — (DCP@MIT-MC)
November 1982

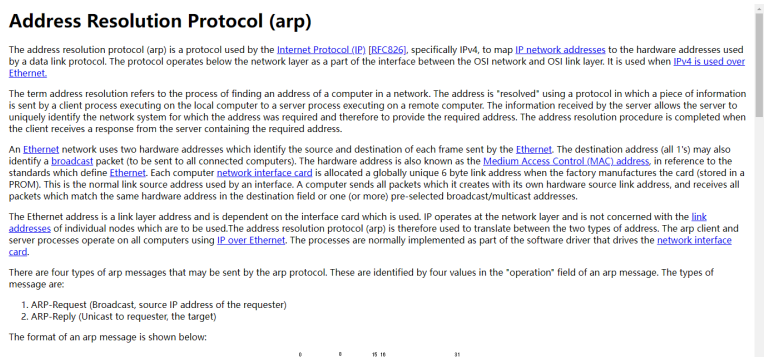
An Ethernet Address Resolution Protocol
-- or --
Converting Network Protocol Addresses
to 48.bit Ethernet Address
for Transmission on
Ethernet Hardware

Abstract

The implementation of protocol P on a sending host S decides, through protocol P's routing mechanism, that it wants to transmit to a target host T located some place on a connected piece of 10Mbit Ethernet cable. To actually transmit the Ethernet packet a 48.bit Ethernet address must be generated. The addresses of hosts within protocol P are not always compatible with the corresponding Ethernet address (being different lengths or values). Presented here is a protocol that allows dynamic distribution of the information needed to build tables to translate an address A in protocol P's address space into a 48.bit Ethernet address.

Generalizations have been made which allow the protocol to be used for non-10Mbit Ethernet hardware. Some packet radio networks are examples of such hardware.

或者可以打开网址如下



Address Resolution Protocol (arp)

The address resolution protocol (arp) is a protocol used by the Internet Protocol (IP) [RFC826], specifically IPv4, to map IP network addresses to the hardware addresses used by a data link protocol. The protocol operates below the network layer as a part of the interface between the OSI network and OSI link layer. It is used when IPv4 is used over Ethernet.

The term address resolution refers to the process of finding an address of a computer in a network. The address is "resolved" using a protocol in which a piece of information is sent by a client process executing on the local computer to a server process executing on a remote computer. The information received by the server allows the server to uniquely identify the network system for which the address was required and therefore to provide the required address. The address resolution procedure is completed when the client receives a response from the server containing the required address.

An Ethernet network uses two hardware addresses which identify the source and destination of each frame sent by the Ethernet. The destination address (all 1's) may also identify a broadcast packet (to be sent to all connected computers). The hardware address is also known as the Medium Access Control (MAC) address, in reference to the standards which define Ethernet. Each computer network interface card is allocated a globally unique 6 byte link address when the factory manufactures the card (stored in a PROM). This is the normal link source address used by an interface. A computer sends all packets which it creates with its own hardware source link address, and receives all packets which match the same hardware address in the destination field or one (or more) pre-selected broadcast/multicast addresses.

The Ethernet address is a link layer address and is dependent on the interface card which is used. IP operates at the network layer and is not concerned with the link addresses of individual nodes which are to be used.The address resolution protocol (arp) is therefore used to translate between the two types of address. The arp client and server processes operate on all computers using IP over Ethernet. The processes are normally implemented as part of the software driver that drives the network interface card.

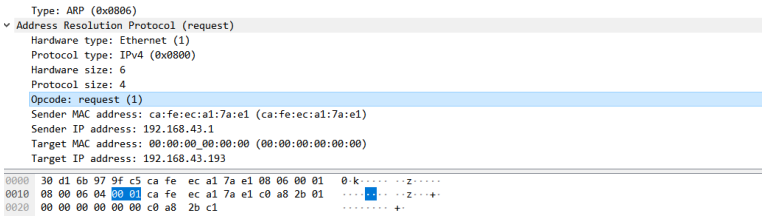
There are four types of arp messages that may be sent by the arp protocol. These are identified by four values in the "operation" field of an arp message. The types of message are:

1. ARP-Request (Broadcast, source IP address of the requester)
2. ARP-Reply (Unicast to requester, the target)

The format of an arp message is shown below:

这两个文件都简略的介绍了 ARP 协议的相关内容

(a)How many bytes from the very beginning of the Ethernet frame does the ARP opcode field begin?



```
    Type: ARP (0x0806)
▾ Address Resolution Protocol (request)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: request (1)
    Sender MAC address: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)
    Sender IP address: 192.168.43.1
    Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Target IP address: 192.168.43.193
```

```
0000  30 d1 6b 97 9f c5 ca fe  ec a1 7a e1 08 06 00 01   0·k····· ··z·····
0010  08 00 06 04 00 01 ca fe  ec a1 7a e1 c0 a8 2b 01   ····.··· ··z···+·
0020  00 00 00 00 00 00 c0 a8  2b c1                     ········ +·
```

我选中了 opcode 项，这里可以看到是从第 21 个字节开始，也就是距离这个以太网帧开头 20 个字节之后。

(b) What is the value of the opcode field within the ARP-payload part of the Ethernet frame in which an ARP request is made?

截图里面有一行 Opcode: request (1)，表示这个 opcode 项的值为 1

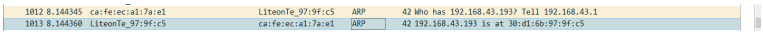
(c) Does the ARP message contain the IP address of the sender?

里面有一行 Sender IP address: 192.168.43.1，表示这个 ARP 报文发送者的 IP 地址为 192.168.43.1

(d) Where in the ARP request does the “question” appear –the Ethernet address of the machine whose corresponding IP address is being queried?

截图里面可以看到 Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00) 以及 Target IP address: 192.168.43.193，表示我需要 IP 地址 192.168.43.193 对应的物理地址，但是这里不知道，物理地址用 00:00:00:00:00:00。从这里可以看到在询问这个 MAC 地址

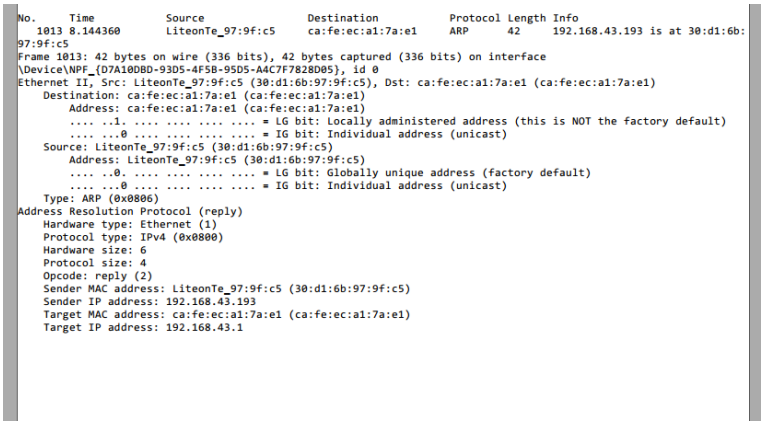
当然如果看这个 info



```
1012 8.144345  ca:fe:ec:a1:7a:e1   LiteonTe_97:9f:c5   ARP   42 Who has 192.168.43.193? Tell 192.168.43.1
1013 8.144360  LiteonTe_97:9f:c5   ca:fe:ec:a1:7a:e1   ARP   42 192.168.43.193 is at 30:d1:6b:97:9f:c5
```

请求报文的 info 里面有一个问题，询问目的 ip 的物理地址，Who has 192.168.43.193? Tell 192.168.43.1

13. Now find the ARP reply that was sent in response to the ARP request. (a) How many bytes from the very beginning of the Ethernet frame does the ARP opcode field begin?

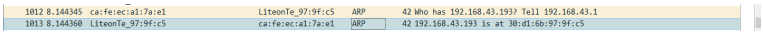


我选中了 opcode 项，这里可以看到是从第 21 个字节开始，也就是距离这个以太网帧开头 20 个字节之后。

(b) What is the value of the opcode field within the ARP-payload part of the Ethernet frame in which an ARP response is made?

截图里面有一行 Opcode: reply (2)，表示这个 opcode 项的值为 2

(c) Where in the ARP message does the “answer” to the earlier ARP request appear –the IP address of the machine having the Ethernet address whose corresponding IP address is being queried?



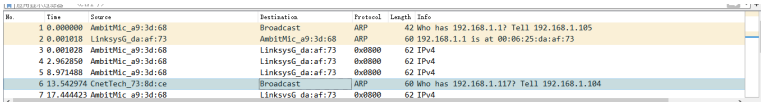
可以看这个 info,响应报文的 info 里面有这个答案,192.168.43.193 is at 30:d1:6b:97:9f:c5,不过这个 info 不知道是在那里储存的 orz, 不过也可以看 Sender MAC address: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5)Sender IP address: 192.168.43.193，也能体现这个 ip 地址对应的物理地址

14. What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP reply message?

源地址 Source: LiteonTe_97:9f:c5 (30:d1:6b:97:9f:c5),目的地址 Destination: ca:fe:ec:a1:7a:e1 (ca:fe:ec:a1:7a:e1)

15. Open the ethernet-ethereal-trace-1 trace file in http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip. The first and second ARP packets in this trace correspond to an ARP request sent by the computer running Wireshark, and the ARP reply sent to the computer running Wireshark by the computer with the ARP-requested Ethernet address. But there is yet another computer on this network, as indicated by packet 6 –another ARP request. Why is there no ARP reply (sent in response to the ARP request in packet 6) in the packet trace?

下面是这个作者提供的 trace file 截图

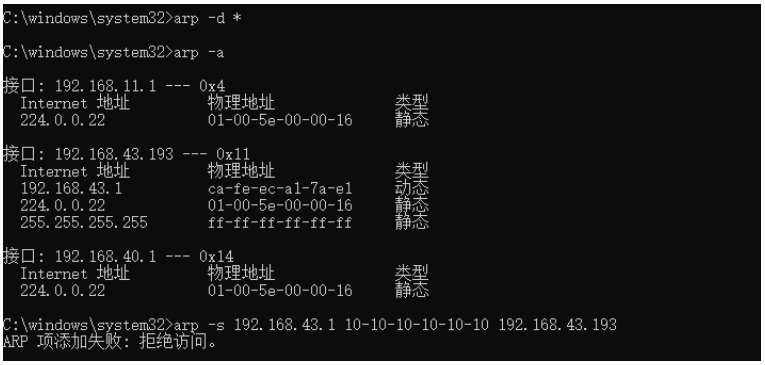


这里第二次没有收到 reply 消息是因为，广播消息是所有这个网络上的主机都能接受到的，但是响应消息是单播的，只有发出该请求的主机才能接收到。

2.3 Extra Credit

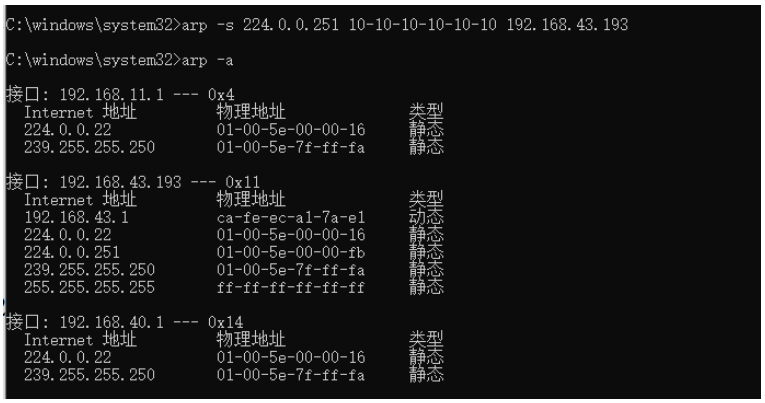
EX-1. The arp command: arp -s InetAddr EtherAddr allows you to manually add an entry to the ARP cache that resolves the IP address InetAddr to the physical address EtherAddr. What would happen if, when you manually added an entry, you entered the correct IP address, but the wrong Ethernet address for that remote interface?

这里我尝试了对已经有的项添加另一个物理地址，那这个物理地址肯定是不对的，得到下面的结果



是拒绝访问

同时我还尝试了，对尚未添加的项，进行添加，并给出错误的物理地址，结果如下

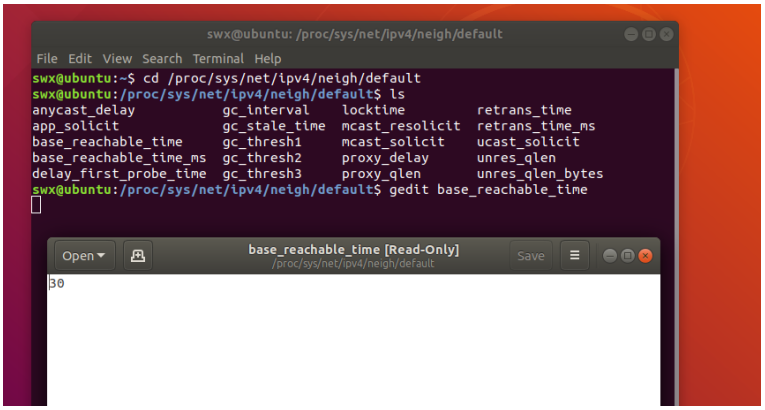


添加的项里面直接把我给的错误物理地址修改为正确的了。

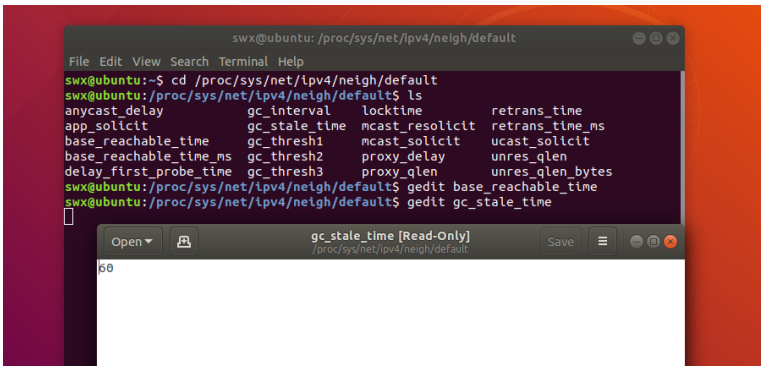
综上，如果插入正确的 ip 地址和错误的 mac 地址，这个会在访问那个 ip 地址时进行更新，修改为正确的

EX-2. What is the default amount of time that an entry remains in your ARP cache before being removed. You can determine this empirically (by monitoring the cache contents) or by looking this up in your operation system documentation. Indicate how/where you determined this value.

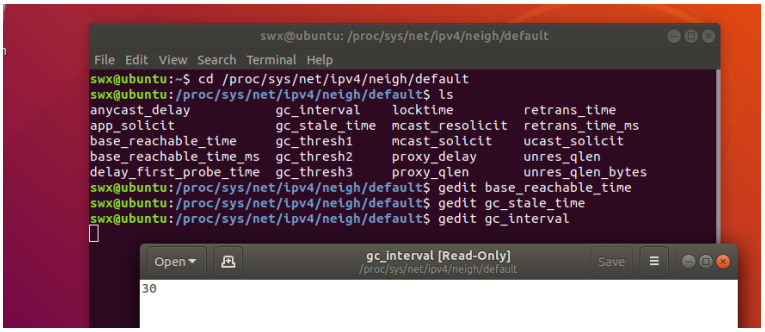
这个我在 win10 系统里面不知道在哪找这个配置文件，但是 Ubuntu 里面比较好找，下面是对应的截图



这个 base_reachable_time 就是这个 arp 项从 reachabe 变成 stale 状态的时间,具体来说是 base_reachable_time /2 到 3* base_reachable_time /2 之间如果该项变成了 stale 状态，只要我们在对这个 ip 发送请求，又会变成



这个 gc_stale_time, 该项是变成 stale 状态后，过多久可以被 gc(garbage collection) 回收



这个 gc_interval 是 gc 进程运行的间隔，每隔 gc_interval 扫描一次。

这些是基本的一些参数，不过实际上这个 ARP 缓存的项的删除还涉及到其他一些复杂的参数和机制，也取决于当时的环境如何，比较复杂 orz