



Concordia University

Engineering and Computer Science

COEN 445

Lab 9

Wireshark Lab: Ethernet and ARP

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Introduction

In this lab, we'll investigate the Ethernet protocol and the ARP protocol. Before beginning this lab, you'll probably want to review sections 5.4.1 (link-layer addressing and ARP) and 5.4.2 (Ethernet) in the book. RFC 826 (<ftp://ftp.rfc-editor.org/innotes/std/std37.txt>) contains the gory details of the ARP protocol, which is used by an IP device to determine the IP address of a remote interface whose Ethernet address is known.

1. Capturing and analyzing Ethernet frames

Let's begin by capturing a set of Ethernet frames to study. Do the following:

- First, make sure your browser's cache is empty. To do this under Mozilla Firefox V3, select *Tools->Clear Recent History* and check the box for Cache. For Internet Explorer, select *Tools->Internet Options->Delete Files*. Start up the Wireshark packet sniffer
- Enter the following URL into your browser
<http://gaia.cs.umass.edu/wireshark-labs/HTTP-ethereal-lab-file3.html>
Your browser should display the rather lengthy US Bill of Rights.

If you are unable to run Wireshark live on a computer, you can download the zip file <http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip> and extract the file *ethernet--ethereal-trace-1*.

1. Capturing and analyzing Ethernet frames (Cont.)

- Stop Wireshark packet capture. First, find the packet numbers (the leftmost column in the upper Wireshark window) of the HTTP GET message that was sent from your computer to gaia.cs.umass.edu, as well as the beginning of the HTTP response message sent to your computer by gaia.cs.umass.edu. You should see a screen that looks something like this (where packet 4 in the screen shot below contains the HTTP GET message)

The screenshot shows the Wireshark interface with a packet capture list and a detailed view of packet 4. The packet list shows the following packets:

No.	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.2.145	128.119.245.12	TCP	2038 > http [SYN] Seq=0 Len=0 MSS=1460
2	0.050606	128.119.245.12	192.168.2.145	TCP	http > 2038 [SYN, ACK] Seq=0 Ack=1 win=5
3	0.050729	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=1 Ack=1 win=65535
4	0.055906	192.168.2.145	128.119.245.12	HTTP	GET /wireshark-labs/HTTP-ethereal-lab-file3.html HTTP/1.1\r\n
5	0.128700	128.119.245.12	192.168.2.145	TCP	http > 2038 [ACK] Seq=1 Ack=453 win=6432
6	0.134167	128.119.245.12	192.168.2.145	TCP	[TCP segment of a reassembled PDU]
7	0.150302	128.119.245.12	192.168.2.145	TCP	[TCP segment of a reassembled PDU]
8	0.150487	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=453 Ack=1762 win=6
9	0.213639	128.119.245.12	192.168.2.145	TCP	[TCP segment of a reassembled PDU]
10	0.215724	128.119.245.12	192.168.2.145	TCP	[TCP Previous segment lost] [TCP segment of a reassembled PDU]
11	0.215947	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=453 Ack=3214 win=6
12	0.231749	128.119.245.12	192.168.2.145	HTTP	[TCP Retransmission] HTTP/1.1 200 OK (text/html)
13	0.232143	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=453 Ack=4510 win=6
14	0.320470	192.168.2.145	128.119.245.12	HTTP	GET /favicon.ico HTTP/1.1\r\n
15	0.403428	128.119.245.12	192.168.2.145	HTTP	HTTP/1.1 404 Not Found (text/html)
16	0.423932	192.168.2.145	168.66.12.224	TCP	2039 > http [SYN] Seq=0 Len=0 MSS=1460
17	0.579522	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=793 Ack=6235 win=6
18	3.383584	192.168.2.145	168.66.12.224	TCP	2039 > http [SYN] Seq=0 Len=0 MSS=1460
19	9.392197	192.168.2.145	168.66.12.224	TCP	2039 > http [SYN] Seq=0 Len=0 MSS=1460
20	10.389131	128.119.245.12	192.168.2.145	TCP	http > 2038 [FIN, ACK] Seq=6235 Ack=793
21	10.389258	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=793 Ack=6236 win=6

The detailed view of packet 4 shows the following information:

- Frame 4 (506 bytes on wire, 506 bytes captured)
- Ethernet II, Src: Netgear_61:8e:6d (00:09:5b:61:8e:6d), Dst: Linksysg_45:90:a8 (00:0c:41:45:90:a8)
- Internet Protocol, Src: 192.168.2.145 (192.168.2.145), Dst: 128.119.245.12 (128.119.245.12)
- Transmission Control Protocol, Src Port: 2038 (2038), Dst Port: http (80), Seq: 1, Ack: 1, Len: 452
- Hypertext Transfer Protocol
 - GET /wireshark-labs/HTTP-ethereal-lab-file3.html HTTP/1.1\r\n
 - Request Method: GET
 - Request URI: /wireshark-labs/HTTP-ethereal-lab-file3.html
 - Request Version: HTTP/1.1
 - Host: gaia.cs.umass.edu\r\n
 - User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.8.1.4) Gecko/20070515 Firefox/2.0.0\r\n
 - Accept: text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5\r\n
 - Accept-Encoding: gzip,deflate\r\n
 - Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\n
 - Keep-Alive: 300\r\n
 - Connection: keep-alive\r\n
 - \r\n

1. Capturing and analyzing Ethernet frames (Cont.)

- Since this lab is about Ethernet and ARP, we're not interested in IP or higher layer protocols. So let's change Wireshark's "listing of captured packets" window so that it shows information only about protocols below IP. To have Wireshark do this, select *Analyze->Enabled Protocols*. Then uncheck the IP box and select *OK*. You should now see an Wireshark window that looks like:

The screenshot shows the Wireshark interface with a list of captured packets. The selected packet (No. 4) is an Ethernet II frame. The detailed view shows the frame structure and the raw data bytes.

No.	Time	Source	Destination	Protocol	Info
1	0.000000	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
2	0.050606	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
3	0.050729	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
4	0.055906	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
5	0.128700	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
6	0.134167	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
7	0.150302	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
8	0.150487	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
9	0.213639	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
10	0.215724	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
11	0.215947	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
12	0.231749	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
13	0.232145	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
14	0.320470	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
15	0.403428	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
16	0.423932	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
17	0.579522	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
18	3.383584	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
19	9.392197	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP
20	10.389131	LinksysG_45:90:a8	Netgear_61:8e:6d	0x0800	IP
21	10.389258	Netgear_61:8e:6d	LinksysG_45:90:a8	0x0800	IP

Frame 4 (506 bytes on wire, 506 bytes captured)
Ethernet II, Src: Netgear_61:8e:6d (00:09:5b:61:8e:6d), Dst: LinksysG_45:90:a8 (00:0c:41:45:90:a8)
Destination: LinksysG_45:90:a8 (00:0c:41:45:90:a8)
Address: LinksysG_45:90:a8 (00:0c:41:45:90:a8)
.....0 = IG bit: Individual address (unicast)
.....0 = LG bit: Globally unique address (factory default)
Source: Netgear_61:8e:6d (00:09:5b:61:8e:6d)
Address: Netgear_61:8e:6d (00:09:5b:61:8e:6d)
.....0 = IG bit: Individual address (unicast)
.....0 = LG bit: Globally unique address (factory default)
Type: IP (0x0800)
Data (492 bytes)

```
0000 00 0c 41 45 90 a8 00 09 5b 61 8e 6d 08 00 45 00 ..AE... [a.m..E.  
0010 01 ec 87 e9 40 00 80 06 38 65 c0 a8 02 91 80 77 ...@... 8e....w  
0020 f5 0c 07 f6 00 50 7a 74 c4 58 7d a6 27 90 50 18 .....Pzt .X)...P.  
0030 ff ff 3a 9c 00 00 47 45 54 20 2f 77 69 72 65 73 .....GE T /wires  
0040 68 61 72 6b 2d 6c 61 62 73 2f 48 54 54 50 2d 65 hark-lab s/HTTP-e  
0050 74 68 65 72 65 61 6c 2d 6c 62 2d 66 69 6c 65 thermal-lab-file  
0060 33 2e 68 74 6d 6c 20 48 54 54 50 2f 32 2e 31 0d 3.html H TTP/1.1.  
0070 0a 48 6f 73 74 3a 20 67 61 69 61 2e 63 72 2e 75 .Host: g aia.cs.u
```

1. Capturing and analyzing Ethernet frames (Cont.)

- In order to answer the following questions, you'll need to look into the packet details and packet contents windows (the middle and lower display windows in Wireshark).

Select the Ethernet frame containing the HTTP GET message. (Recall that the HTTP GET message is carried inside of a TCP segment, which is carried inside of an IP datagram, which is carried inside of an Ethernet frame; reread section 1.5.2 in the text if you find this encapsulation a bit confusing). Expand the Ethernet II information in the packet details window. Note that the contents of the Ethernet frame (header as well as payload) are displayed in the packet contents window.

1. What is the 48-bit Ethernet address of your computer?
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.]
3. Give the hexadecimal value for the two-byte Frame type field. What upper layer protocol does this correspond to?
4. How many bytes from the very start of the Ethernet frame does the ASCII "G" in "GET" appear in the Ethernet frame?

1. Capturing and analyzing Ethernet frames (Cont.)

Next, answer the following questions, based on the contents of the Ethernet frame containing the first byte of the HTTP response message.

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?
6. What is the destination address in the Ethernet frame? Is this the Ethernet address of your computer?
7. Give the hexadecimal value for the two-byte Frame type field. What upper layer protocol does this correspond to?
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?

2. The Address Resolution Protocol

In this section, we'll observe the ARP protocol in action. We strongly recommend that you re-read section 5.4.1 in the text before proceeding.

ARP Caching

Recall that the ARP protocol typically maintains a cache of IP-to-Ethernet address translation pairs on your computer. The *arp* command (in both MSDOS and Linux/Unix) is used to view and manipulate the contents of this cache. Since the *arp* command and the ARP protocol have the same name, it's understandably easy to confuse them. But keep in mind that they are different - the *arp* command is used to view and manipulate the ARP cache contents, while the ARP protocol defines the format and meaning of the messages sent and received, and defines the actions taken on message transmission and receipt.

Let's take a look at the contents of the ARP cache on your computer:

- **MS-DOS.** The *arp* command is in `c:\windows\system32`, so type either "*arp*" or "`c:\windows\system32\arp`" in the MS-DOS command line (without quotation marks).
- **Linux/Unix/MacOS.** The executable for the *arp* command can be in various places. Popular locations are `/sbin/arp` (for linux) and `/usr/etc/arp` (for some Unix variants).

The Windows *arp* command with no arguments will display the contents of the ARP cache on your computer. Run the *arp* command.

2. The Address Resolution Protocol (Cont.)

9. Write down the contents of your computer's ARP cache. What is the meaning of each column value? In order to observe your computer sending and receiving ARP messages, we'll need to clear the ARP cache, since otherwise your computer is likely to find a needed IP-Ethernet address translation pair in its cache and consequently not need to send out an ARP message.

- **MS-DOS.** The MS-DOS `arp -d *` command will clear your ARP cache. The `-d` flag indicates a deletion operation, and the `*` is the wildcard that says to delete all table entries.
- **Linux/Unix/MacOS.** The `arp -d *` will clear your ARP cache. In order to run this command you'll need root privileges. If you don't have root privileges and can't run Wireshark on a Windows machine, you can skip the trace collection part of this lab and just use the trace discussed earlier.

2. The Address Resolution Protocol (Cont.)

Observing ARP in action

Do the following:

- Clear your ARP cache, as described above.
- Next, make sure your browser's cache is empty. To do this under Mozilla Firefox V3, select *Tools->Clear Recent History* and check the box for Cache. For Internet Explorer, select *Tools->Internet Options->Delete Files*.

- Start up the Wireshark packet sniffer
- Enter the following URL into your browser

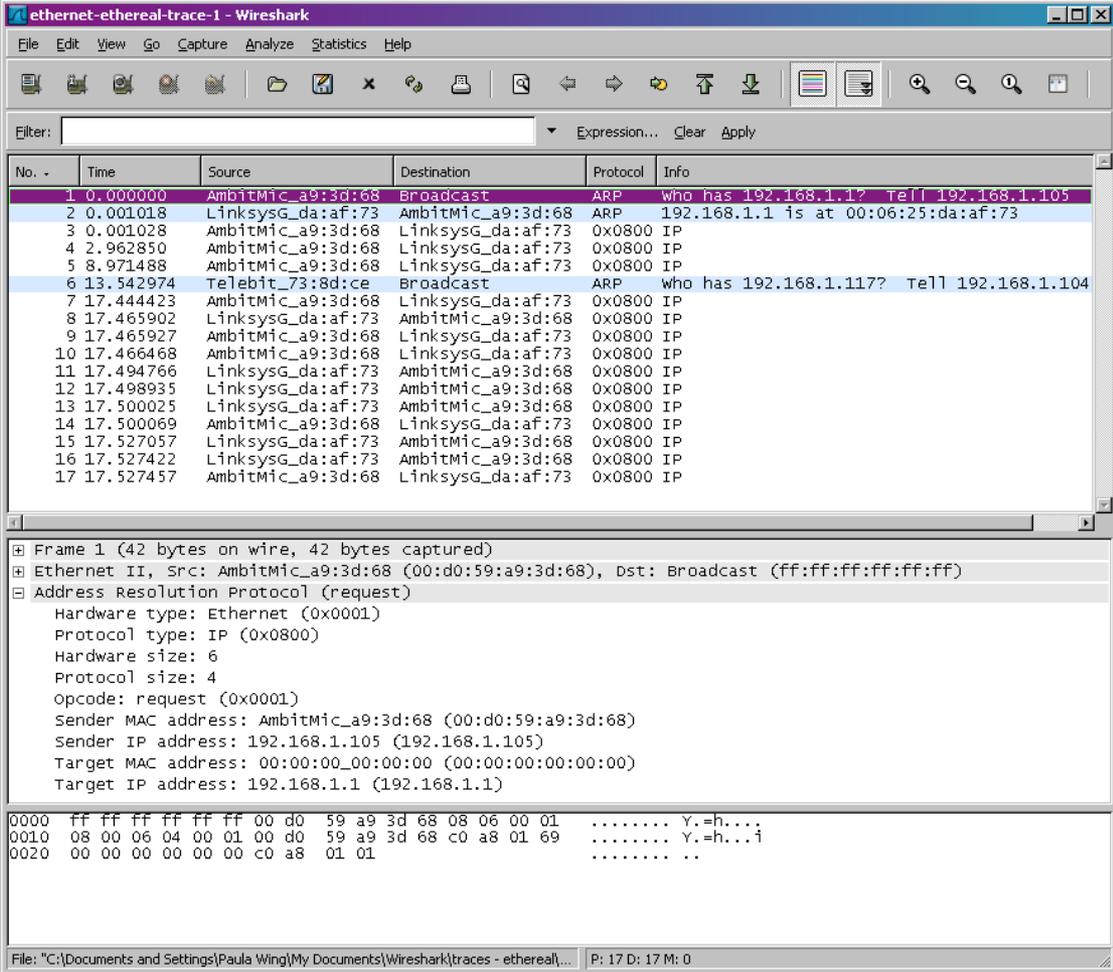
<http://gaia.cs.umass.edu/wireshark-labs/HTTP-wireshark-lab-file3.html>

Your browser should again display the rather lengthy US Bill of Rights.

- Stop Wireshark packet capture. Again, we're not interested in IP or higher-layer protocols, so change Wireshark's "listing of captured packets" window so that it shows information only about protocols below IP. To have Wireshark do this, select *Analyze->Enabled Protocols*. Then uncheck the IP box and select *OK*.

2. The Address Resolution Protocol (Cont.)

You should now see an Wireshark window that looks like:



The screenshot shows the Wireshark interface with a packet capture of an ARP request. The packet list pane shows 17 packets, with packet 1 selected. The packet details pane shows the structure of the ARP request, including Ethernet II, Address Resolution Protocol (request), and the specific fields like Sender MAC, Sender IP, Target MAC, and Target IP. The packet bytes pane shows the raw hex and ASCII data.

No.	Time	Source	Destination	Protocol	Info
1	0.000000	AmbitM1c_a9:3d:68	Broadcast	ARP	who has 192.168.1.1? Tell 192.168.1.105
2	0.001018	LinksysG_da:af:73	AmbitM1c_a9:3d:68	ARP	192.168.1.1 is at 00:06:25:da:af:73
3	0.001028	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
4	2.962850	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
5	8.971488	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
6	13.542974	Telebit_73:8d:ce	Broadcast	ARP	who has 192.168.1.117? Tell 192.168.1.104
7	17.444423	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
8	17.465902	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
9	17.465927	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
10	17.466468	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
11	17.494766	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
12	17.498935	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
13	17.500025	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
14	17.500069	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	
15	17.527057	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
16	17.527422	LinksysG_da:af:73	AmbitM1c_a9:3d:68	0x0800 IP	
17	17.527457	AmbitM1c_a9:3d:68	LinksysG_da:af:73	0x0800 IP	

Frame 1 (42 bytes on wire, 42 bytes captured)
Ethernet II, Src: AmbitM1c_a9:3d:68 (00:d0:59:a9:3d:68), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Address Resolution Protocol (request)
Hardware type: Ethernet (0x0001)
Protocol type: IP (0x0800)
Hardware size: 6
Protocol size: 4
opcode: request (0x0001)
Sender MAC address: AmbitM1c_a9:3d:68 (00:d0:59:a9:3d:68)
Sender IP address: 192.168.1.105 (192.168.1.105)
Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
Target IP address: 192.168.1.1 (192.168.1.1)

```
0000 ff ff ff ff ff ff 00 d0 59 a9 3d 68 08 06 00 01 ..... Y.=h...
0010 08 00 06 04 00 01 00 d0 59 a9 3d 68 c0 a8 01 69 ..... Y.=h...i
0020 00 00 00 00 00 00 c0 a8 01 01 ..... ..
```

2. The Address Resolution Protocol (Cont.)

In the example above, the first two frames in the trace contain ARP messages (as does the 6th message).

Answer the following questions:

10. What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP request message?
11. Give the hexadecimal value for the two-byte Ethernet Frame type field. What upper layer protocol does this correspond to?
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>.
 - a) How many bytes from the very beginning of the Ethernet frame does the ARP *opcode* field begin?
 - 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?
 - c) Does the ARP message contain the IP address of the sender?

2. The Address Resolution Protocol (Cont.)

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

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?



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