

CS 372 Introduction to Computer Networks

Lab # 4

Due Sunday, 11:59pm, Friday of Week 8.

Submit to Canvas before midnight.

Name: _____

Wireshark Lab: Ethernet and ARP v6.01

Supplement to *Computer Networking: A Top-Down Approach*, 6th ed., J.F. Kurose and K.W. Ross

“Tell me and I forget. Show me and I remember. Involve me and I understand.” Chinese proverb

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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 text¹. RFC 826 (<http://ftp.rfc-editor.org/in-notes/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 following²:

- 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.
- 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 the following (where packet 4 in the screen shot below contains the HTTP GET message)

¹References to figures and sections are for the 6th edition of our text, *Computer Networks, A Top-down Approach*, 6th ed., J.F. Kurose and K.W. Ross, Addison-Wesley/Pearson, 2012. ² 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*. The traces in this zip file were collected by Wireshark running on one of the author's computers, while performing the steps indicated in the Wireshark lab. Once you have downloaded the trace, you can load it into Wireshark and view the trace using the *File* pull down menu, choosing *Open*, and then selecting the *ethernet-ethereal-trace-1* trace file. You can then use this trace file to answer the questions below.

(Untitled) - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

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
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	0.232145	192.168.2.145	128.119.245.12	TCP	2038 > http [ACK] Seq=453 Ack=4810 win=6
14	0.320470	192.168.2.145	128.119.245.12	HTTP	GET /favicon.ico HTTP/1.1
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

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/2.0.0.4\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-Language: en-us,en;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

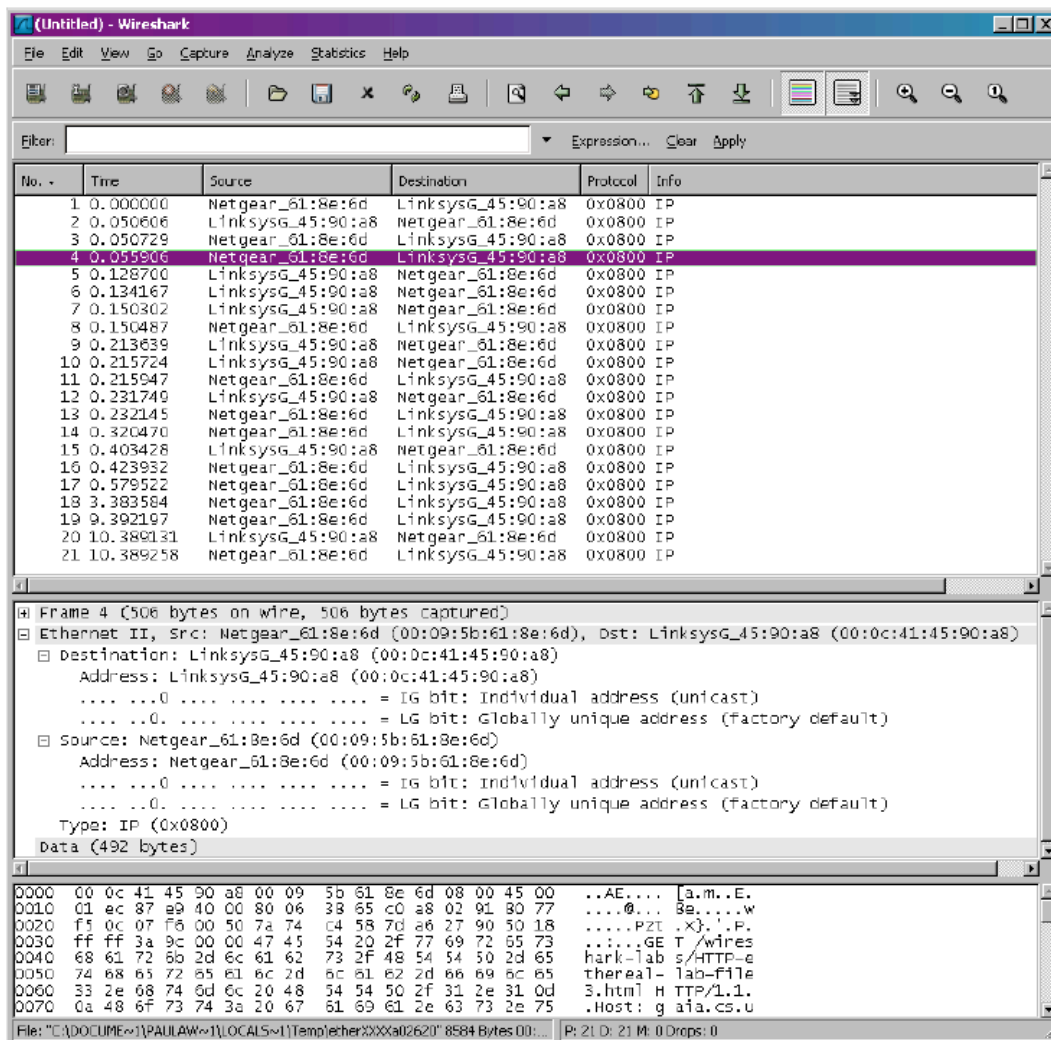
Keep-Alive: 300\r\n

Connection: keep-alive\r\n

\r\n

0040 68 61 72 65 2d 6c 61 62 73 2f 48 54 54 50 2d 65hark-lab s/HTTP-e
0050 74 68 65 72 65 61 6c 2d 6c 61 62 2d 66 69 6c 65thereal- lab-file
0060 23 2e 68 74 6d 6c 20 48 54 54 50 2f 31 2e 31 0d3.html H TTP/1.1.
0070 0a 48 6f 73 74 3a 20 67 61 69 61 2e 63 73 2e 75Host: g aia.cs.u
0080 6d 61 73 73 2e 65 64 75 0d 0a 55 73 65 72 2d 41mass.edu ..User-A
0090 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6c 61 2f 35 2egent: Mo zilla/5.
P: 21 D: 21 M: 0 Drops: 0

- 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:



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.

Answer the following questions, based on the contents of the Ethernet frame containing the HTTP GET message. Whenever possible, when answering a question you should hand in a printout of the packet(s) within the trace that you used to answer the question asked. Annotate the printout³ to explain your answer. To print a packet, use *File->Print*, choose *Selected packet only*, choose *Packet summary line*, and select the minimum amount of packet detail that you need to answer the question.

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?

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?

³What do we mean by “annotate”? If you hand in a paper copy, please highlight where in the printout you’ve found the answer and add some text (preferably with a colored pen) noting what you found in what you’ve highlight. If you hand in an electronic copy, it would be great if you could also highlight and annotate.

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.

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 in the earlier footnote.

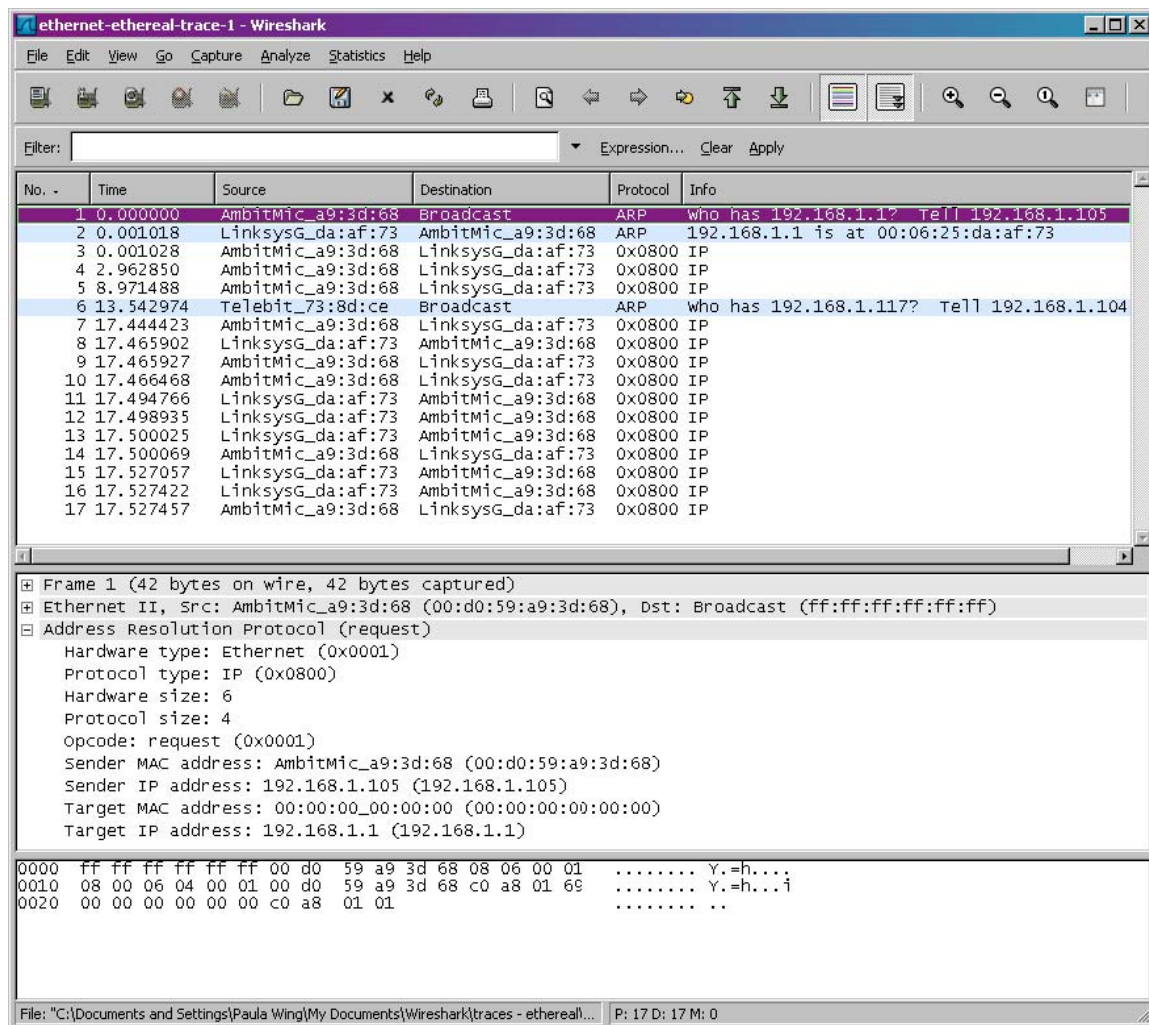
Observing ARP in action

Do the following⁴:

- 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

⁴ The *ethernet-etherreal-trace-1* trace file in <http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip> was created using the steps below (in particular after the ARP cache had been flushed).

- 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*. You should now see an Wireshark window that looks like:



In the example above, the first two frames in the trace contain ARP messages (as does the 6th message). The screen shot above corresponds to the trace referenced in footnote 1.

Answer the following questions:

- What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP request message?
- 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?
 - d) Where in the ARP request does the “question” appear – the Ethernet address of the machine whose corresponding IP address is being queried?
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?
 - 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?
 - 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?
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-etherreal-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?

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?

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 operating system documentation. Indicate how/where you determined this value.