

**ECE435: Network Engineering – Homework 7**  
Internet Protocol v4 / v6

**Due: Friday, 25 March 2022, 5:00pm**

For this homework short answers will suffice.

To submit, create a document with your answers (text, pdf, libreoffice, MS Office if you must) and e-mail them to *vincent.weaver@maine.edu* by the homework deadline. Title your e-mail “ECE435 Homework 7” and be sure your name is included in the document.

1. If you recall from previous homeworks we looked at a packet similar to this:

```
0x0000:  0013 3b10 667f b827 eba8 3711 0800 4500  ..;.f..'..7...E.
0x0010:  0038 572a 4000 4006 69cc c0a8 0833 826f  .8W*@.@.i....3.o
0x0020:  2e7f bda5 0050 cdc4 6a49 3c7b 6ca5 8018  ....P..jI<{1...
0x0030:  00e5 79f4 0000 0101 080a 0104 3e58 34a8  ..y.....>X4.
0x0040:  7bc3 4745 540a                                {.GET.
```

The IPv4 header begins at offset 0xe.

Fill in the name of the field as well as decode the value. Use decimal when decoding if it makes sense, provide units if necessary, and if the value decoded has a meaning (such as a flag of pre-defined value) say what it means.

For help decoding the IPv4 header see the class notes or else RFC791.

BEGIN IPv4 HEADER	Name of Field	Decoded Value
0x000e: 4		
0x000e: 5		
0x000f: 00		
0x0010: 0038		
0x0012: 572a		
0x0014: 4000		
0x0016: 40		
0x0017: 06		
0x0018: 69cc		
0x001a: c0a8 0833		
0x001e: 826f 2e7f		
END IPv4 HEADER		

2. Which of the following are valid IPv4 addresses?
  - (a) 123.267.67.44
  - (b) 8.8.8.8
  - (c) 3232237569
  - (d) 0xc0a80801
  
3. Early internet adopters got large IPv4 allocations. For example Ford (the car company) owned all of 19.0.0.0/8. What percentage of the entire IPv4 space is that? (Somewhat related, this old xkcd comic gives an interesting map of the IPv4 situation at the time: <https://xkcd.com/195/>)
  
4. A network is described as 192.168.13.0/24.
  - (a) What would be the subnet mask for this subnet?
  - (b) What would be the lowest IP address you could assign on this subnet?
  - (c) What would be the highest IP address you could assign on this subnet?
  
5. Traditionally on Linux you could use the `route` command to find out the IP routing information for a system. Here are the results from a Raspberry Pi on one of my networks.

```
pi3:~$ /sbin/route
Kernel IP routing table
Destination      Gateway          Genmask         Flags Metric Ref    Use Iface
default          192.168.8.2     0.0.0.0         UG    0      0      0 eth0
192.168.8.0     0.0.0.0         255.255.255.0  U     0      0      0 eth0
```

The `route` command is now considered deprecated and you can now find the same info with the `ip route` command

```
pi3:~$ ip route
default via 192.168.8.2 dev eth0 proto dhcp src 192.168.8.138 metric 202
192.168.8.0/24 dev eth0 proto dhcp scope link src 192.168.8.138 metric 202
```

- (a) If a packet is sent to 216.58.192.132, what is its first “hop” on the way?
  - (b) If a packet is sent to 192.168.8.50 what is its first “hop” on the way?
  
6. Use the “ping” command on a network connected machine to `ping www.google.com`. (If you don’t have access to a machine with ping on traceroute available, let me know and I can provide access)
  - (a) What is the round-trip packet time?
  - (b) Do you notice anything odd about the hostname that responds?

7. Use the “traceroute” command. It’s tracert on Windows.

(a) `tracert www.maine.edu`.

How many hops away is it? Do you recognize any of the names in the hops along the way?

(b) `tracert www.facebook.com`.

How many hops away is it? Do the response times gradually go up for each further hop?

## 8. Network Address Translation

(a) You use `tcpdump` to monitor your network and see packets such as this go by:

```
16:58:49.108396 00:13:3b:10:66:7f (oui Unknown) >
00:50:b6:47:1c:de (oui Unknown), ethertype IPv4 (0x0800),
length 141: google-public-dns-a.google.com.domain >
macbook-air.51415: 30858 2/0/0
CNAME pagead46.l.doubleclick.net., A 172.217.7.130 (99)
```

where `macbook-air` has the address `192.168.8.38` and it is connecting to IP `8.8.8.8`.

Is it normal for an address like `192.168.8.38` to be able to connect directly to `8.8.8.8`? Why or why not?

What is the likely reason this is working?

(b) You can use the `netstat-nat` command on a Linux machine doing NAT to see all of the nat connections. Some sample output is below.

Proto	NATed Address	Destination Address	State
tcp	macbook-air:51908	49.246.178.107.bc.google:https	ESTABLISHED
tcp	macbook-air:55194	iad23s63-in-f19.1e100.ne:https	ESTABLISHED
tcp	macbook-air:42334	206-140.amazon.com:https	TIME_WAIT
tcp	macbook-air:52930	104.16.78.166:https	ESTABLISHED
tcp	macbook-air:57928	akamai-1-s.net.maine.edu:http	ESTABLISHED
udp	macbook-air:58903	google-public-dns-a.goo:domain	ASSURED
udp	macbook-air:49779	google-public-dns-a.goo:domain	ASSURED
udp	macbook-air:44416	google-public-dns-a.goo:domain	UNREPLIED
udp	pi2:ntp	clock.xmission.com:ntp	ASSURED
udp	pi2:ntp	38.88.18.251:ntp	ASSURED
udp	pi2:ntp	tock.no-such-agency.net:ntp	ASSURED

One of the UDP connections is listed as `UNREPLIED`. Why might the NAT firewall track whether a UDP packet has been replied to or not?

## 9. IPv6

(a) Which of the following are valid IPv6 addresses?

- i. 2607:f8b0:4009:0801:0000:0000:0000:200e
- ii. 2607:f8b0:4009:801::200e
- iii. 2607:f8b0::4009:801::200e
- iv. 123.45.67.189

(b) We used tcpdump to gather the following network frame.

```
tcpdump port 53 -xe -i eth1 -XX
```

```
0x0000:  8875 563d 2a80 0030 18ab 1c39 86dd 6002  .uV=*...0...9..`.
0x0010:  2618 0031 1140 2610 0048 0100 08da 0230  &...1.@&..H.....0
0x0020:  18ff feab 1c39 2001 4860 4860 0000 0000  .....9..H`H`....
0x0030:  0000 0000 8844 e239 0035 0031 9c0e 8657  .....D.9.5.1...W
0x0040:  0120 0001 0000 0000 0001 0377 7777 0465  .....www.e
0x0050:  7370 6e03 636f 6d00 0001 0001 0000 2910  spn.com.....).
0x0060:  0000 0000 0000 00
```

The IP header starts at address 0xe. From the value found there you suspect this is an IPv6 packet, so use the class notes or RFC2460 to decode the various fields. Decode to decimal if it makes sense, report what fields or flags stand for, be sure to report units if necessary.

BEGIN IPv6 HEADER	Name of Field	Decoded Value
0x000e: 6		
0x000f: 00		
0x0010: 2            2618		
0x0012: 0031		
0x0014: 11		
0x0015: 40		
0x0016: 2610 0048    0100 08da 0230 18ff    feab 1c39		
0x0026: 2001 4860    4860 0000 0000 0000    0000 8844		
END IPv6 HEADER		

## 10. Traceroute and Routing

- (a) You traceroute `www.cam.ac.uk` which is at Cambridge University in England. And get the following:

```
1 VL218.gw-um-pri.net.maine.edu (130.111.218.2) 0.374 ms 0.348 ms 0.307 ms
2 bell.gw-oro.net.maine.edu (130.111.0.4) 0.999 ms 1.032 ms 1.039 ms
3 * * *
4 et-7-0-0.4079.rtsw.bost.net.internet2.edu (162.252.70.97) 17.577 ms 17.588 ms 17.551 ms
5 et-7-0-0.4079.rtsw.hart2.net.internet2.edu (162.252.70.99) 19.066 ms 19.105 ms 19.069 ms
6 ae-2.4079.rtsw.newy32aoa.net.internet2.edu (162.252.70.101) 20.499 ms 18.767 ms 18.748 ms
7 198.71.45.237 (198.71.45.237) 107.802 ms 107.225 ms 107.193 ms
8 ae5.mx1.lon2.uk.geant.net (62.40.98.178) 91.941 ms 92.040 ms 91.945 ms
9 ae6.mx1.lon.uk.geant.net (62.40.98.36) 92.102 ms 92.289 ms 92.270 ms
10 janet-gw.mx1.lon.uk.geant.net (62.40.124.198) 92.238 ms 92.384 ms 92.371 ms
11 ae28.lowdss-sbr1.ja.net (146.97.33.18) 95.822 ms 96.973 ms 95.453 ms
12 ae26.lowdss-ban1.ja.net (146.97.35.246) 96.520 ms 96.495 ms 96.483 ms
13 uoc.ja.net (146.97.41.38) 97.665 ms 97.786 ms 99.185 ms
14 d-dw.s-dw.net.cam.ac.uk (193.60.88.2) 98.901 ms 98.939 ms 98.624 ms
15 d-dw.s-dw.net.cam.ac.uk (193.60.88.2) 98.401 ms 98.327 ms 98.296 ms
16 s-dw.f-sv-net.net.cam.ac.uk (128.232.128.2) 98.015 ms 99.126 ms 97.903 ms
```

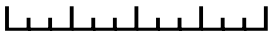

- i. Can you tell which hop takes you across the Atlantic Ocean?
- ii. Can you guess what city this happens in based on the hostnames?

- (b) Back in 2018 you ran `traceroute6 www.cam.ac.uk` which traces the same connection, but with IPv6, and you get the following (for some reason IPv6 doesn't seem to be working from my office anymore and I haven't had time to debug why):

```
1 vl218.gw-o-neville.net.maine.edu (2610:48:100:8da::1) 1.957 ms 1.908 ms 2.068 ms
2 gi7-2.gw-orono.net.maine.edu (2610:48::25) 0.769 ms 0.680 ms 0.836 ms
3 2610:48:0:a::9 (2610:48:0:a::9) 0.774 ms 1.004 ms 0.943 ms
4 2610:48:0:a::2 (2610:48:0:a::2) 21.907 ms 21.967 ms 21.878 ms
5 et-4-1-0.4072.rtsw.wash.net.internet2.edu (2001:468:ff:a02::2) 30.120 ms 30.076 ms 29.928 ms
6 abilene-wash.mx1.fra.de.geant2.net (2001:798:14:10aa::11) 126.785 ms 130.140 ms 126.743 ms
7 ae1.mx1.ams.nl.geant.net (2001:798:cc:1401:2201::a) 120.872 ms 124.076 ms 120.840 ms
8 ae2.mx1.lon.uk.geant.net (2001:798:cc:2801:2201::1) 119.811 ms 116.640 ms 119.732 ms
9 janet-gw.mx1.lon.uk.geant2.net (2001:798:28:10aa::2) 129.290 ms 116.694 ms 129.300 ms
10 ae29.londpg-sbr2.ja.net (2001:630:0:10::1ca) 120.310 ms 117.270 ms 117.199 ms
11 ae30.londtw-sbr2.ja.net (2001:630:0:10::1ce) 120.909 ms 139.899 ms 139.835 ms
12 2001:630:0:10::17e (2001:630:0:10::17e) 120.647 ms 123.732 ms 133.303 ms
13 2001:630:0:1000:10::75 (2001:630:0:1000:10::75) 120.475 ms 120.632 ms 120.669 ms
14 2001:630:0:9000::2 (2001:630:0:9000::2) 123.632 ms 120.554 ms 120.494 ms
15 b-ec.c-ce.net.cam.ac.uk (2001:630:210:3::1) 133.603 ms 133.565 ms 133.567 ms
16 c-ce.d-dr.net.cam.ac.uk (2001:630:210:19::2) 124.555 ms 124.511 ms 133.799 ms
17 d-dr.s-dw.net.cam.ac.uk (2001:630:210:2002::2) 133.760 ms 121.897 ms d-dr.s-dr.net.cam.ac.uk (2001:630:210:2002::2)
18 mws-83481.mws3.csx.cam.ac.uk (2001:630:212:8::8c:90) 133.478 ms 133.416 ms 133.175 ms
```

- i. Why are there be a different number of hops compared to IPv4?
- ii. Is the latency better or worse when using IPv6? Why might this be?

Not a question, but you might know enough about IP networking now to find this novelty notepad amusing:

<b>Internet Protocol Datagram</b>		<b>RFC791</b>
Source 	Destination 	Version <input type="checkbox"/> <i>If other than version 4, attach form RFC 2460.</i>
<b>Type of Service</b> <input type="checkbox"/> high reliability <input type="checkbox"/> high throughput <input type="checkbox"/> low delay	<b>Precedence</b> <input type="checkbox"/> Routine <input type="checkbox"/> Priority <input type="checkbox"/> Immediate <input type="checkbox"/> Flash <input type="checkbox"/> Flash Override <input type="checkbox"/> CRITIC/ECP <input type="checkbox"/> Internetwork Control <input type="checkbox"/> Network Control	<b>Fragmentation</b> <b>Offset</b> <i>Transport layer use only</i> <input type="checkbox"/> more to follow <input type="checkbox"/> do not fragment <input type="checkbox"/> this bit intentionally left blank Identifier _____
<b>Protocol</b> <input type="checkbox"/> TCP <input type="checkbox"/> UDP <input type="checkbox"/> Other _____	<b>Length</b> <b>Header Length</b> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<b>Data</b> <i>Print legibly and press hard. You are making up to 255 copies.</i> _____ _____ _____ _____ _____ _____
<b>Time to Live</b> <b>Options</b> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <span style="border: 1px solid black; padding: 2px;"><i>Do not write in this space.</i></span>	<b>Header Checksum</b> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	

for more info, check IPv4 specifications at <http://www.ietf.org/rfc/rfc0791.txt>