Exercise #6

Switching & Traceroute
1. Packet switching

- $7.5 \times 10^6$ bits to transfer over the network
- Transfer rate: 1.5 Mbps
- $7.5 \times 10^6 = 7.5$ Mb
- *Store and forward!*

1a. No segmentation

- 7.5 Mb at 1.5 Mbps ⇒ 5s to transfer data over one link
1a. No segmentation

- 7.5 Mb at 1.5 Mbps ⇒ 5s to transfer data over one link

Time: 5 s
1a. No segmentation

- 7.5 Mb at 1.5 Mbps ⇒ 5s to transfer data over one link

Time: 10 s
1a. No segmentation

- 7.5 Mb at 1.5 Mbps ⇒ 5s to transfer data over one link

Time: 15 s
1b/c. Segmentation

- 1500 bits per packet $\Rightarrow$ 7.5 Mb / 1.5 kb = 5 k packets
- 1 ms per packet transfer
- After 3 ms: 4999 packets to go! $\Rightarrow$ 4999 more ms

Time: 5002 ms

$5.002s/15s \approx \frac{1}{3}$!
1d. Disadvantages of segmentation

- The packets may arrive out-of-sequence. Need to handle reordering.

- Need an additional header for each packet. Increased overhead.
2. Traceroute: Theory

a) “...Three probes (by default) are sent at each ttl setting and a line is printed showing the ttl, address of the gateway and round trip time of each probe...”

b) “…This program attempts to trace the route an IP packet would follow to some internet host by launching probe packets with a small ttl (time to live) then listening for an ICMP "time exceeded" reply from a gateway...”

The hop did not reply with TIME EXCEEDED messages.
3.1 Traceroute: Practice

```
$ sudo traceroute -M icmp mit.edu
traceroute to mit.edu (23.211.148.210), 30 hops max, 60 byte packets
 1 rou-cx-1-lsec-cx-dock-1-a.ethz.ch (192.33.93.1)  0.775 ms  0.939 ms  1.159 ms
 2 rou-ref-hci-bb-ref-hci-cx.ethz.ch (10.10.1.81)  0.856 ms  1.096 ms  1.376 ms
 3 rou-fw-hci-lnf-lsec.ethz.ch (10.1.17.242)  0.999 ms  1.196 ms  1.476 ms
 4 rou-fw-rz-fw-hci.ethz.ch (192.33.92.185)  0.916 ms  1.071 ms  1.403 ms
 5 rou-fw-rz-gw-rz.ethz.ch (192.33.92.170)  1.227 ms  1.389 ms  1.550 ms
 6 swiez2.ethz.ch (192.33.92.11)  0.711 ms  0.768 ms  0.762 ms
 7 zch-b2-link.telia.net (213.248.79.189)  0.981 ms  0.976 ms  0.965 ms
 8 ffn-bb3-link.telia.net (62.115.142.110)  6.779 ms  6.880 ms  6.891 ms
 9 ffn-b12-link.telia.net (02.115.142.47)  0.515 ms  0.533 ms  0.532 ms
10 ** *
```

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Length</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>15:03:32.905</td>
<td>EliteGold 3c:0:e:2:1c</td>
<td>Broadcast</td>
<td>ARP</td>
<td>66</td>
<td>Who has 192.33.3.147 Tell 192.33.3.194</td>
</tr>
<tr>
<td>76</td>
<td>15:03:45.588</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>77</td>
<td>15:03:41.427</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.147 Tell 192.33.3.194</td>
</tr>
<tr>
<td>78</td>
<td>15:03:45.666</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>79</td>
<td>15:03:45.616</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>80</td>
<td>15:03:45.657</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>81</td>
<td>15:03:45.678</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>82</td>
<td>15:03:45.717</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>83</td>
<td>15:03:45.758</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>84</td>
<td>15:03:45.779</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
<tr>
<td>85</td>
<td>15:03:45.819</td>
<td>Cisco_e3:0:41</td>
<td>Broadcast</td>
<td>ARP</td>
<td>68</td>
<td>Who has 192.33.3.167 Tell 192.33.3.51</td>
</tr>
</tbody>
</table>

**Frame 1:** 118 bytes on wire (888 bytes), 118 bytes captured (888 bytes) on interface 6
- **Ethernet II Src:** D:0:c9:6c:4e:7a:00, Dst: 00:5e:00:02:01:00 (ether type 0x806)
- **Internet Protocol Version 6, Src:** 2001:0c7::6986:003:0000, Dst: 2001:0c7::6986:003:0000
- **User Datagram Protocol, Src Port:** 123, Dst Port: 4059
- **Network Time Protocol (NTp Verson 4, server)

```
wireshark_pcap_0336_2019040812354_724f4.pcapng
```
```
$ sudo traceroute -M icmp mit.edu
traceroute to mit.edu (23.211.148.218), 30 hops max, 60 byte packets
  1 rou-cx-1-lnf-lsec-cx-dock-1-a.ethz.ch (192.33.93.1)  0.775 ms  0.939 ms  1.159 ms
  2 rou-ref-hci-bb-ref-hci-cx.ethz.ch (10.10.1.81)  0.856 ms  1.096 ms  1.376 ms
  3 rou-fw-hci-lnf-lsec.ethz.ch (10.1.17.242)  0.999 ms  1.196 ms  1.476 ms
  4 rou-fw-rz-fw-hcl.ethz.ch (192.33.92.185)  0.910 ms  1.071 ms  1.403 ms
  5 rou-fw-rz-gw-rz.ethz.ch (192.33.92.170)  1.227 ms  1.389 ms  1.550 ms
  6 swize2.ethz.ch (192.33.92.11)  0.711 ms  0.768 ms  0.762 ms
  7 zch-b2-link.telta.net (213.248.79.189)  0.981 ms  0.970 ms  0.965 ms
  8 ffn-bb3-link.telta.net (62.115.142.110)  6.779 ms  6.800 ms  6.891 ms
  9 tfn-b12-link.telta.net (62.115.142.47)  6.515 ms  0.533 ms  0.532 ms
 10 * * *
```
```
$ sudo traceroute mit.edu
traceroute to mit.edu (88.221.9.235), 30 hops max, 60 byte packets
  1 rou-cx-1-lnf-lsec-cx-dock-1-a.ethz.ch (192.33.93.1)  1.259 ms  1.378 ms  1.590 ms
  2 rou-ref-hci-bb-ref-hci-cx.ethz.ch (18.10.1.81)  0.826 ms  1.137 ms  1.663 ms
  3 rou-fw-hcl-lnf-lsec.ethz.ch (10.1.17.242)  1.847 ms  1.318 ms  1.591 ms
  4 rou-fw-rz-fw-hcl.ethz.ch (192.33.92.185)  0.956 ms  1.154 ms  1.328 ms
  5 rou-fw-rz-gw-rz.ethz.ch (192.33.92.170)  1.169 ms  1.290 ms  1.481 ms
  6 swize2.ethz.ch (192.33.92.11)  0.747 ms  0.822 ms  0.822 ms
  7 zch-b2-link.telta.net (213.248.79.189)  1.068 ms  1.063 ms  1.042 ms
  8 adm-bb3-link.telta.net (62.115.135.122)  22.852 ms  22.754 ms  22.849 ms
  9 adm-bb3-link.telta.net (213.155.136.28)  37.423 ms  37.264 ms  37.473 ms
 10 adm-b2-link.telta.net (213.155.137.211)  31.969 ms  31.377 ms adm-b2-link.telta.net (62.115.118.145)  31.377 ms adm-b2-link.telta.net (62.115.112.123)  37.817 ms
 11 akamai-tc-342259-adm-b2.c.telta.net (62.115.171.197)  27.838 ms  27.777 ms  27.790 ms
```
```
Frame 72: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0

Ethernet II, Src: 00:17:24:26:01:41, Dst: 18:17:24:26:01:41


Type: IPv4 (0x0800)

Internet Control Message Protocol

Type: 11 (Time-to-live exceeded)
Code: 0 (Time to live exceeded in transit)
Checksum: 0xb4ed [correct]


User Datagram Protocol, Src Port: 55967, Dst Port: 33440

Source Port: 55967

Destination Port: 33440

[Expert Info (Chat/Sequence): Possible traceroute: hop #2, attempt #3]

Length: 40
Checksum: 0xe2a0 [unverified]
[Checksum Status: Unverified]
[Stream index: 10]