- **Problem 1** (7 points) **Due by 17:00, Feb. 27**

  1. Use packet analyzing tools like `wireshark` or `tcpdump` to capture an ICMP destination unreachable message from one of the four networks `172.x.0.0/16` and show the captured message.
  2. Use packet analyzing tools like `wireshark` or `tcpdump` to capture an ICMP redirect message from one of the four networks `172.x.0.0/16`; show the captured ICMP redirect messages; and show the changes of the routing cache and the routing paths caused by the ICMP redirect message.
  3. Select a pair of hosts A and B, one in network `net17` and one in network `net18`. Use `tracepath6` on A to test the reachability of B. Use packet analyzing tools like `wireshark` or `tcpdump` to capture an IPv6 datagram in `net17` or `net18` which carries the data from your `tracepath6` request, and capture an IPv4 datagram in `net16` or `net19` which carries an IPv6 datagram for the `tracepath6`. Show the captured datagrams.

  Hints:

  You need to use packet analyzing tools like `wireshark` or `tcpdump` to capture the targeted messages. You may need to read the manuals for `wireshark` or `tcpdump` before you start working on the assignment. The following web sites might be helpful: `www.wireshark.org` and `www.tcpdump.org`. To run `wireshark` or `tcpdump`, you need to use `sudo` command (e.g., `sudo wireshark`). You may put your commands for testing into scripts. You probably can not run `wireshark` or `tcpdump` on any of the four routers. So please test your program on a client machine which is not a router.

  To get an ICMP destination unreachable message, you may need to shut down a network interface of one host and try to reach the down interface from another host. You may use `ifdown eth1` to shut down interface `eth1` and `ifup eth1` to turn up interface `eth1`. You may need to use `sudo` to run `ifup` and `ifdown`. On the IPv6 enabled hosts, you may get an error message when you run `ifdown`. In this case, you can use `ifconfig eth1 down` to shut down interface `eth1` and use `ifconfig eth1 up && ifup eth1` to turn up `eth1`.

  Warning: Never turn down interface `eth0` of any client machine. Especially if you turn down `eth0` of a machine remotely, you disconnect the machine from network `192.168.0.0/24` and may not be able to resume the connection.

  Never turn down any network interface or change the routing table of any routers (**december, january, february, march**), because this will cause trouble to others who are testing their programs.

  Please restore the machines to their original configurations using `ifdown` and `ifup` once you finished your work.

  A router R issues an ICMP redirect message to a host H if R forwards a packet P sent by H to the same interface from which P is received. For example, the gateway for the default route in the routing tables of the machines connected to `172.18.0.0/16` is set to

`march.net18`. If you force a packet (to be routed by the default route) from a machine connected to `172.18.0.0/16`, say `May`, to be sent to `december.net18`, then `December` will receive this packet from interface `eth2` and forward the received packet to `march.net18` through the same interface `eth2`. In this case, `December` sends `May` an ICMP redirect message.

You need to modify the routing table on a host H to cause the above problem and to observe the changes of the routing cache at H and routing path. You can use `ip route` or `route` command (with `-C` option) to view the contents of a routing cache. To show the changes of the routing cache clearly, you may need to clear the routing table first (using `ifdown` and `ifup`) and then change its contents. You may need `sudo` for changing routing tables.

To show a routing path, you may use `tracepath` or `ping -R` commands.

Networks `net17` and `net18` support both IPv4 and IPv6, while networks `net16` and `net19` support IPv4 only. An IPv6 datagram from `net17` (resp. `net18`) to network `net18` (resp. `net17`) has to go through network `net16` or `net19` (IPv4 tunnel). In this case, the IPv6 datagram is encapsulated in an IPv4 datagram which is transmitted in `net16` or `net19`.

Consult with `man` pages for the related commands.

Your scripts must work in the virtual network and the output must be the data from the virtual network.

You need to submit your programs to the directory `/assignment/2/yourid` in the gateway machine `cs-vnl-e01.csil.sfu.ca` by 17:00 Feb. 27. Please have clear comments in your shell scripts to explain how they work.

Problem 2: (0 points) Solving the following problems will help you to understand the masterials we have discussed. Please ask if you have any question.

1. Binary trie is a data structure used for efficient address lookup at a routing table. Assume that a routing table has the following network addresses: `00010`, `10010`, `00100`, `01010`, `11010`, and `10110`. Draw a binary trie for looking up the network addresses in this routing table.

2. Assume that an IPv4 datagram D with 1120 bytes of data is fragmented at a router into two datagrams, D_1 with the 1st 640 bytes of the data in D and D_2 with the rest data. Let M_1 and M_2 be the *the more fragment bits* in the IP headers of D_1 and D_2, respectively. Let Off_1 and Off_2 be *the fragmentation offsets* in the IP headers of D_1 and D_2, respectively. Give the values of M_1, M_2, Off_1, Off_2.

3. Describe briefly how ARP works and give the ARP message format.

4. Assume that networks N_1 and N_2 are connected by router R which performs Proxy ARP to allow N_1 and N_2 to use a same network address. Describe how a host A connected to network N_1 sends a datagram to a host B connected to network B_2 via Proxy ARP.

5. In the domain name space, the names of machines are defined in a tree structure with the `root` at the top. Each node in the tree is assigned a label called domain name. A machine's full domain name is a sequence of domain names from a leaf node to a child of the `root` deparated by dot. Find the global IP address of a gateway to the virtual network lab. Draw the subtrees of the tree that define the full domain name and the inverse domain name for the gateway.

6. In the virtual networks, `seasons` is the only machine that runs DNS server. The DNS server related files can be found at `/etc/bind/` at `seasons`. Study these files and give the tree which defines the hierarchical domain space and machine names connected to networks `net16, net17, net18, net19`.

   Does the DNS server provides name to IPv6 address service? Verify your answer by a test in the vertual networks.

7. TCP uses positive acknowledgment and retransmission for reliable transmissions. Does a lost data segment always cause a retransmission? Does a lost ACK message always cause a retransmission? Explain briefly your answers.

8. TCP uses 32 bits for data stream sequence numbers. How does this allow a stream of arbitrary length transmitted? How many bytes can a stream have if each byte in the stream must be assigned a distinct sequence number?

9. Assume that both the sender and the receiver in a TCP connection has a window size of k bytes. What is the minimum number of distinct sequence numbers for the stream in the TCP connection such that every byte in the stream can be uniquely identified at both sides?

10. The sender in a TCP connection is using a window size of 1000 and the previous ACK number is 2000. Now the sender receives a segment with ACK number 2500 and window size 800. Show the changes of the sender's window by figures. Show the changes of the window if the window size in the received ACK segment is 1200.