- **Problem 1** (7 points) **Due by 17:00, March 16**

  You need to submit your **programs** and the **executable codes** to the directory `/assignment/3/yourid` in the gateway machine `cs-vnl-e01.csil.sfu.ca` by 17:00 March 16. Please have clear comments in your programs to explain how they work.

  1. Write socket programs (client and server) to create a TCP connection. You may use JAVA or C++ for your socket programs. If you want to use a language different from JAVA/C++, please get your TA's approval.

     Use packet analyzing tools like `wireshark` or `tcpdump` to capture from one of the four networks `172.x.0.0/16` the segments in the TCP connection created by your socket programs exclusively, and submit the **captured segments**. The captured segments should include those for the connection establishment, data transfer, and the connection termination.

     Use packet analyzing tools to observe the TCP retransmission and submit the **captured retransmitted fragments**. (Hint, you may need to set-up a TCP connection and then to obstruct it by turning down a network interface used in the connection.)

     Never turn down any interface in any of the routers **December, January, February, or March**. Please restore the turned-down interface after your testing.

     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`.

     Please restore the machines to their original configurations using `ifdown` and `ifup` once you finished your work (on the IPv6 enabled hosts, you may use `ifconfig eth1 down` to shut down interface `eth1` and use `ifconfig eth1 up && ifup eth1` to turn up `eth1`).

     Your programs must work in the virtual networks and the output must be the data from the virtual networks.

  2. An autonomous system (AS) consisting of routers $R_1, ..., R_6$ and networks $N_1, ..., N_7$, where Router R_i is connected to Networks N_i and N_{i+1} for $1 \leq i \leq 6$. Assume that RIP is used as the interior routing protocol on every router of the AS. Write a program (in JAVA or C++) to simulate the operations of RIP on every router.

     The RIP on each router periodically sends its routing table to its neighbors. On receiving a routing table from a neighbor, the RIP updates its routing table. To make the simulation simple, we may assume that routers operate (send routing tables) in a specific order, for example, in the order of $R_1, R_2, R_3, R_4, R_5, R_6$ in one round of operations and repeat the operations in the same order in the subsequent rounds. We assume that the routing table at each router is updated immediately on receiving the table from a neighbor router and the update is completed before the next operation.

     For each entry of the routing table in a router, there should be at least three values: destination network, next hop router, and the number of hops to the destination. Your program should generate the data of the routing tables on every router at beginning of each round of operations until the routing table at every router converges.

     Your programs must work in the virtual networks.

3. Use the AS and modify the program in the previous question to simulate the instability of RIP. We assume that right after R_1 sends out its routing table in the 1st round of operations, R_1 detects Network N_1 is disconnected and changes its routing table accordingly. Your modified program should generate the data of the routing tables on every router at beginning of each round of operations until the routing table at every router converges.

   Your programs must work in the virtual networks.

- **Problem 2** (0 point)

1. Assume that a client machine obtained a leased IP address by DHCP for a network connection. The client closed this connection to the network and stored the leased IP address in the disk. The client machine wants to re-connect to the nework by the stored IP address. Is this always possible? Explain your answer.
2. Explain by figures the TCP three way handshake for connection establishment and the modified three way handshake for connection termination.
3. Assume that a source in a TCP connection has sent k segments and obtained the round trip time $RTT(i), = 1, 2, ..., k$. The TCP computes a smoothed round trip time for segment $k + 1$: $SRTT(k + 1) = \alpha \times SRTT(k) + (1 - \alpha) \times RTT(k)$ and $SRTT(1) = RTT(1)$. Express $SRTT(k+1)$ in terms of $RTT(1), RTT(2), ..., RTT(k)$. $SRTT(k+1)$ is a weighted average of the previous k round trip times. For a constant $\alpha = 0.8$ and a large k (say $k > 10$), which round trip time has the largest weight in the average?
4. What techniques are used in TCP to response the congestion? Explain these techniques.
5. Below is the RIP routing table of a router:

Destination	next-hop-router	hops
N1	R2	4
N2	R3	2
N3	R3	1
N4	R4	5

   The router receives the following message from a neighbor router $R2$ and updates its routing table.

Destination	hops
N1	7
N2	3
N3	5
N4	3
N5	5

   Show the updated routing table.

6. RIP uses distance vector routing algorithm. Explain how the distance routing algorithm updates the routing table in the previous question.
7. Give the weighted directed graph used by OSPF for representing the AS in Figure 1. Give the routing table of Router R_5 computed by OSPF, the metric in the routing table is the link-state (delay).

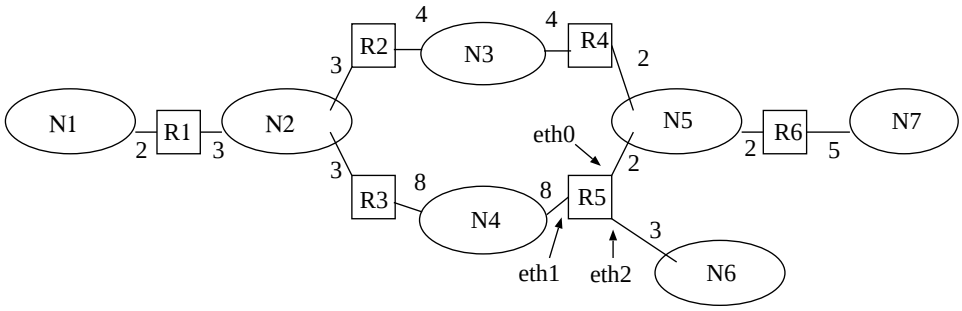

Figure 1: An autonomous system.

8. Study the example of an AS in RFC 1131 and explain why partition the AS into areas would reduce the traffics generated by OSPF.
9. Describe how loops in paths can be detected in BGP.
10. Assume that routers $R_0 \rightarrow R_1 \rightarrow R_2 \rightarrow R_3$ form an MPLS routing path from R_0 to R_3, the flow of datagrams from R_0 to R_3 is given label 1, and the flow of datagrams from R_1 to R_2 is given label 2. Show the labels and the S bit in the MPLS headers attached to a datagram in the flow from R_0 to R_1, from R_1 to R_2, and from R_2 to R_3, respectively.