- **Problem 1** (6 points) **Due by 17:00, March 9**

  You need to submit your **programs** and the **executable codes** to the directory
  `/Assignment/3/yourid` in the gateway (`cs-vnl-01.csil.sfu.ca`, `cs-vnl-02.csil.sfu.ca`,
  `cs-vnl-03.csil.sfu.ca` or `cs-vnl-04.csil.sfu.ca`) by the due time. Please have clear
  comments in your programs to explain how they work.

  1. (4 points) 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 tool `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 tool `tcpdump` to observe the TCP retransmission and submit the
     captured retransmitted segments. You may need to set-up a TCP connection and
     then to obstruct it by turning down the network interface `eth1` used in the connection
     by `sudo ifdown eth1`. **Please turn up** the interface you turned down using `sudo
     ifup eth1` once you have captured the retransmitted segments.

     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`.

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

  2. (2 points) An autonomous system (AS) consisting of routers $R_1, ..., R_7$ and networks
     $N_1, ..., N_8$, where Router R_i is connected to Networks N_i and N_{i+1} for $1 \leq i \leq 7$.
     Assume that RIP is used as the interior routing protocol on every router of the AS.
     Write a program (in JAVA or C++) and run your program on a single client machine
     in the virtual network to simulate the operations of RIP on each of routers $R_1, ..., R_7$.

     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 $R_1, R_2, R_3, R_4, R_5, R_6, R_7$ 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 of $R_1, .., R_7$ at
     beginning of each round of operations until the routing table at every router converges.

     Hint: You simply write and run a simulation program on any client in the virtual
     network. You may use one procedure P_i to simulate the operations of router R_i in one
     round and call these procedures in the order specified above (e.g., $P_1, P_2, P_3, P_4, P_5, P_6, P_7$)

in your program for one round of operations of the routers. Your program must work in one client in the virtual network.

- **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 obtained k round trip time samples $RTT(i), i = 1, 2, ..., k$. The TCP computes a smoothed round trip time based on the k samples: $SRTT(k+1) = \alpha \times SRTT(k) + (1-\alpha) \times RTT(k)$ and $SRTT(2) = RTT(1)$. 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	2
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. Explain briefly why RIP restricts the maximum hops to 15.

  8. Explain briefly the instability problem in RIP.

9. 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).
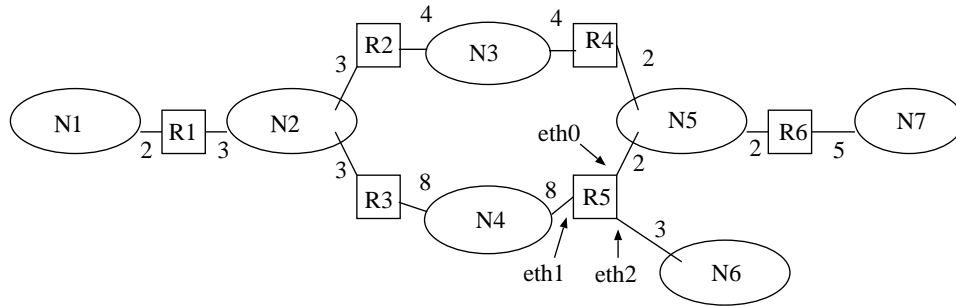

Figure 1: An autonomous system.

10. Study the example of an AS in RFC 1131 and explain why partition the AS into areas would reduce the traffics generated by OSPF.

11. Describe how loops in paths can be detected in BGP.

12. Assume that routers $R_0 \to R_1 \to R_2 \to R_3$ 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.