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 network 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:

<table>
<thead>
<tr>
<th>Destination</th>
<th>next-hop-router</th>
<th>hops</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>R2</td>
<td>4</td>
</tr>
<tr>
<td>N2</td>
<td>R3</td>
<td>2</td>
</tr>
<tr>
<td>N3</td>
<td>R3</td>
<td>2</td>
</tr>
<tr>
<td>N4</td>
<td>R4</td>
<td>5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Destination</th>
<th>hops</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>7</td>
</tr>
<tr>
<td>N2</td>
<td>3</td>
</tr>
<tr>
<td>N3</td>
<td>5</td>
</tr>
<tr>
<td>N4</td>
<td>3</td>
</tr>
<tr>
<td>N5</td>
<td>5</td>
</tr>
</tbody>
</table>

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).

![Diagram of an autonomous system]

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 $R_0 \rightarrow R_1 \rightarrow R_2 \rightarrow R_3$ 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.