CSE 123: Computer Networks
Homework 4
Out: 12/03 Due: 12/10

Instructions
1. Turn in a physical copy at the beginning of the class on 12/10
2. Ensure the HW cover page has the following information clearly written
   a. Name
   b. UCSD email
   c. PID

1. Routers and QoS

<table>
<thead>
<tr>
<th>Packet #</th>
<th>Size</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>240</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
<td>3</td>
</tr>
</tbody>
</table>

Suppose a router has three input flows and one output. It receives the packets listed in the table above all at about the same time, in the order listed, during a period in which the output port is busy but all queues are otherwise empty.

Give the order in which the packets are transmitted for
a. Fair queuing.
   b. Weighted fair queuing with flow 2 having twice as much share as flow 1, and flow 3 having 1.5 times as much share as flow 1.

Note: Resolve ties in the order of flow 1, flow 2, and flow 3.
2. **Congestion Avoidance: RED**
   Consider a RED gateway with MaxP = 0.02, and with an average queue length halfway between the two thresholds.
   a. Find the drop probability \( P_{\text{count}} \) for \( \text{count} = 10 \) and \( \text{count} = 50 \).
   b. Calculate the probability that none of the first 10 packets are dropped.

3. **Congestion Control and Congestion Avoidance**
   a. What is the main benefit that RED provides when compared to drop-tail?
   b. What is the difference between congestion avoidance and congestion control?
   c. Assume we have a simple network with 5 hosts and a router. The router connects each of the 5 hosts in a star topology. The RTT between each pair of hosts is 10 ms. Each host uses a simple UDP query and response protocol (i.e., each packet sent to a destination results in a single packet being sent back to the sender) to communicate between hosts. Additionally, if a sender does not receive a response within 20 ms, it retransmits the request. Multiple requests can be outstanding at one time, but each request will be retransmitted until a response is received.

   Assume that the router queue is empty at the beginning. All hosts start sending requests to each other at a very high (fixed) rate. Very shortly thereafter, we notice a congestion collapse. Briefly explain (however, please be precise about your assumptions) whether each of the following techniques, if implemented, would affect/prevent the congestion collapse?

   i. Double the timeout value from 20 ms to 40 ms.
   ii. Double the size of the queue in the router.
   iii. If a query is not answered within a timeout interval, multiplicatively reduce the maximum rate at which the client sends query packets.
   iv. Use a flow control window at each receiver to prevent buffer overruns.

4. **Network Address Translation**
   Network Address Translation, NAT, is the translation of an Internet Protocol address (IP address) used within one network to a different IP address known within another network.
   a. Why do we need NAT? Why is it a service that is present on many routers today?
   b. NAT is considered to be a temporary solution. What technology when deployed will do away with the need of NAT?

Recall, a NAT capable router essentially translates private address within a network to public addresses that can be used publicly. In this question, we try and understand the working behind a simple NAT capable router. A simple NAT capable router will have mappings between the private addresses within the network (here, the private
addresses all fall within the 10/8 network) to the public address(es) that it uses. Let us assume that the router has a single public address 138.76.29.7 which it uses for all communication with hosts that are not part of the private network. The router multiplexes its public IP address(es) as needed and keeps track of the multiplexing in a NAT translation table.

Assume that the router multiplexes the public address using ports starting from 8000 and then incrementing by one. For example, if a host in the private network with address 10.0.0.5:5000 sends a message to 132.239.8.45:80 then the entry in the NAT table would be filled in as below. The next time the router will use 8001 as the port to establish a new connection and so on.

<table>
<thead>
<tr>
<th>NAT Translation Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAN Side Address</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>138.76.29.7:8000</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

c. What would be the entries in the NAT Translation Table at the end of the following events:
   i. 10.0.0.6:5000 sends a message to 74.125.239.33:80
   ii. 10.0.0.10:6000 sends a message to 204.79.197.200:80
   iii. 10.0.1.101:6001 sends a message to 206.190.36.45:80
   iv. 10.0.0.10:6000 sends another message to 204.79.197.200:80
   v. 10.0.1.101:6001 sends a message to 74.125.239.33:80
   vi. 10.0.0.7:7000 sends a message to 63.245.215.20:80
   vii. 204.79.197.200:80 sends a message to 10.0.0.10:6000
   viii. 206.190.36.45:80 sends a message to 74.125.239.33:80

   Note: The NAT Table should like the one above with the entries generated from the events in (c.) filled in

d. For simplicity, let us assume that message format is MSG<Sender, Receiver>. In that case, if a host in the private network with address 10.0.0.5:5000 sends a message to 132.239.8.45:80 then the message received at the router and leaving at the router would look as follows:
   Message Received from Host: MSG<10.0.0.5:5000, 132.239.8.45:80>
   Message Sent from Router: MSG<138.76.29.7:8000, 132.239.8.45:80>

   Note: We will need to use the entries from the table we filled in (c.) to do this.
List out the message received from the host at the router and the message sent from the router (like shown above) for the following messages:

1. 10.0.0.6:5000 sends a message to 74.125.239.33:80
2. 10.0.0.10:6000 sends a message to 204.79.197.200:80

e. If the router gets a message
   MSG<74.125.239.33:80,138.76.29.7:8001>, what would the message look like leaving the router?

f. Finally, if the router gets a message MSG<10.0.0.10:6000, 10.0.1.101:6001>, what would the message look like leaving the router?