<u>CMPE 570/670 HW #1</u>

Due Thursday 09/16/2021

(First a side note for those interested: recommended reading to see one historical perspective into protocol layering: Russell, A.L., "The internet that wasn't," *IEEE Spectrum*, vol.50, no.8, pp. 39, 43, August 2013)

1. (10 pts) <u>About paper "OSI Reference Model-The IS0 Model of Architecture for Open Systems Interconnection"</u>: (a) What is "Layering"? (include a definition and at least two defining principles); (b) Describe five of the ideas/principles that guided the design of the OSI Reference Model into seven layers.

2. (10 pts) <u>About paper "The evolution to 4G cellular systems: LTE-Advanced":</u> Fig. 3 shows the protocol layer architecture for a 4G cellular networks. Consider the layers only in the "Access Stratum" part, and the related explanation below the figure. You will notice that most of the layers were not present in the OSI architecture. Considering that the protocol stack in Fig. 3 relates to the wireless connection between the mobile and the base station only and not a complete end-to-end network, what layer or layers from the OSI architecture do you think correspond to the layers in Fig. 3? Highlight at least two functions in the layers that you think are especially for wireless mobile connections.

3. (15 pts) Consider sending a single message of 10,000 bytes from a sending host to a receiving host with three intermediate routers. Assume that the message will wait for two other same size messages to finish transmission at each intermediate router. Also assume that the total distance between the sender and the receiver is 1000 km (0.3 km/μsec) and the transmission capacity is 10 Mbps along the path. Calculate the time from the first bit being sent out from the sender and the last bit received by the receiver. Specify clearly any assumption made in your calculations.

   Next suppose that the receiver is managing a buffer where received data is temporarily placed until being processed. When there is only a certain number of bytes left free in the buffer, the receiver will need to send a message back to the data source to request a stop of transmission and avoid a buffer overflow. Calculate this number of bytes and indicate how this magnitude is called.

4. (15 pts) Consider a network design problem: What is the minimum link capacity to transfer successfully a 1MB file over a network with 2 intermediate nodes within 1 second? The length of any link between any two pair of nodes is 200 km. All links use fiber optics (speed of light is $c=2.10^8$ m/s). Assume that the processing delay is negligible and that at each intermediate node the message will have to wait for four other same size messages to finish transmission.

5. (50 pts) In this exercise you will use a script for Matlab to experiment with a queue. For all the questions in this exercise, you will need to configure and run the Matlab script "`queue_sys_dcom.m`" that you will find in myCourses. The script simulates a small network with 7 nodes. Node 1 sends data to node 6 and node 2 sends data to node 7. Nodes 3, 4 and 5 are routing nodes. You will only look into the queue of node 4. This node is

routing all the traffic it receives to node 6, which in turn, is only generated from node 1. In the Matlab script you should be able to identify a section where the nodes are being configured with different parameters. In this section, the data traffic generated from node 1 is configured as:

- `node(1).lambda = 500;`
- `node(1).avgpcklen = 1000;`

This configuration means that node 1 will generate 500 packets/sec on average and these packets will have a random number of bits with a mean size of 1000 bits/packet. Therefore, node 1 will generate **at the input of node 4** an average traffic bit rate of 500kbps (this is called the “arrival rate” in queueing terminology).

a) (10 points) As said, the size of packets generated by node 1 is random variable. Generate a plot with the histogram of the packets size. You can do this by running the script as given and the executing the following Matlab instructions:

```
pz=node(4).pcktsz(find(node(4).pcktsz>0));
[numpz,pzbin]=hist(pz,100);
plot(pzbin,numpz);grid;xlabel('Packet Size');
```

The plot you will see will be analogous to the probability density function of a random variable and should resemble a very common function that gives name to the probability distribution that determines the packet sizes. Which random variable do you think this one is?
(Hint: you can also find out what probability distribution is by examining Matlab’s script at line 118).

b) (10 points) Run the Matlab script by changing the output bit rate from node 4 (called the “service rate” in queuing terminology. You will be able to do this by changing the script line “`node(4).out_bps = 1e6;`” (here configuring the bit rate to 1Mbps. Use for your simulations the output bit rate values of: 2Mbps, 1.5Mbps, 1Mbps, 750kbps, 666.667kbps, 600kbps, 555.556kbps and 450kbps. For each simulation run:

- Measure the average time a packet spends in node 4. You can accomplish this by running the following instructions:

```
timeinsys=node(4).TimeInNode(find(node(4).TimeInNode~=0));

mean(timeinsys)
```

- Measure the average number of packets waiting in node 4’s queue using the command: “`mean(node(4).qlen)`”

- Plot the number of packets in the queue as a function of time using the command “`plot(node(4).qlen);grid`”. Is the number of packets a bounded number (this is, the number of packets in the queue does not have a long-term trend of increasing to infinity)? Why?

c) (15 points) Plot your measurements of the average time a packet spends in node 4 as a function of the service rate. What do you observe? Why? NOTE: Do not include in this plot your measurement for service rate 450kbps.

d) (15 points) Plot your measurements of the average number of packets waiting in node 4's queue as a function of the service rate. What do you observe? Why? NOTE: Do not include in this plot your measurement for service rate 450kbps.