ASSIGNMENT 2

EE673A DIGITAL COMMUNICATION NETWORKS

2023-2024 (Odd)

14th September 2023 Deadline: 8th October 2023

Instructions:

1. Submissions are to be made through the HelloIITK portal
2. You must submit a single zip file containing well-commented and easy-to-understand codes and a single PDF (containing answers to theory questions if required). There should also be a readme file with clear instructions on how to run the codes.
3. Kindly name your submission file as <RollNo>_<Name>, eg: 18204269_LavishArora
4. 10% Marks will be deducted for all submissions that do not follow the above guidelines.

Question 1: Wireshark Labs

Attempt the TCP and UDP sections of the Wireshark Labs from the reference material Computer Networking A Top-Down Approach 6th Edition by Kurose and Ross (Links are given below). You are required to submit the answers for the questions that are part of the above Labs.

TCP: t.ly/vcH6 [*7.5 marks*]
UDP: t.ly/K2RS [*2.5 marks*]

Question 2: Studying TCP Congestion Control in NetSim

NetSim is a simulation and emulation tool for network design and planning. It also provides tools for protocol and network modeling. Let us follow the preliminary setup before diving into the problem.

1. Install NetSim[1] on your system using the instructions given here[2], make sure all the sub-modules like Wireshark and winPcap are selected during the installation procedure.
2. Go through the introduction to NetSim (pdf and videos)
3. Go through introduction to TCP using NetSim (pdf and videos)

Once you are done with the preliminaries let us simulate a basic network to study various TCP Congestion Control algorithms. Take the following steps to setup the network

1. Client and Server are connected by a lossy link with the topology shown in the figure 1.
2. An FTP application seeks to transfer large file using TCP
3. Use the configuration in Tab.1 to set the network parameters

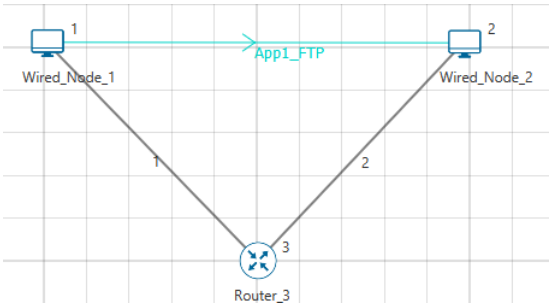


Figure 1: Network topology

[1]NetSim is only available for windows, if you are using macOS or Linux you can install and run netsim in a virtual machine.

[2]Installation instructions: https://www.iitk.ac.in/nt/faq/netsim.htm

Table 1: Simulation Parameters

Link Parameters	
Wired link speed	10 Mbps
Wired link BER	1e-7
Wired link propogation delay	25 msecs
Transport Layer Parameters	
Transport Protocol	TCP
Congestion Control	Old_Tahoe, Reno, Cubic
MSS	1460
Application Parameters	
Application	FTP
File Size	1e8 Bytes
Miscelleaneous	
Simulation Time	20 secs
Wireshark	Enabled On

After setting up the network run the simulation for different congestion control algorithms mentioned in the table. For each algorithm plot the window size vs time through Wireshark capture. In your answer for this question, display, compare and comment on the three plots. Which Congestion control algorithm is able to utilize the link capacity to its maximum? [*30 marks*]

Question 3: Network Queuing Simulation

In this exercise, we will simulate a network queue and visualize the queue size under various network traffic conditions.

Consider a single user communicating through a network router with a fixed transmission capacity($R = 5$ bits/second). At each time instant, the user communicates with probability p. If the user is communicating at time t, it generates a packet of size either $a = 2, b = 4, c = 6$ or $d = 8$ bits with probability $p_a,\ p_b,\ p_c$ and p_d respectively with $p_a + p_b + p_c + p_d = 1$

Part A: Simulate the above problem and plot [*15 marks*]

1. average queue length (in bits) vs p
2. average packet delay vs p

(varying p from 0 to 1) for the following cases:

(i) $p_a = p_b = p_c = p_d = 0.25$

(ii) $p_a = p_d = 0, p_b = p_c = 0.5$

(iii) $p_a = p_d = 0.5, p_b = p_c = 0$

(iv) $p_a = p_b = p_c = 0, p_d = 1$

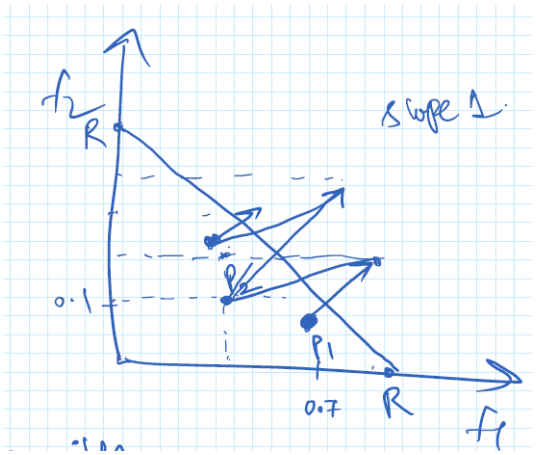
Part B: Answer the following questions: *[5 marks]*

(a) For each of the above case, what is the expected number of incoming bits at time t as a function of p, i.e, if X is the number of arrival bits in a given time slot, what is $E[X]$ for each of the above cases as a function of p? Also, find the variance of X, for each of the above four cases.

(b) In which of above case the incoming communication traffic (i.e., expected number of arriving bits in a time slot) exceeds the network capacity for $p = 1$?

Question 4 : TCP Fairness

Simulate the calculations and generate the plot discussed in the class about TCP fairness (shown below for your reference), which indicates that TCP is fair. You can either use Python/Matlab to do this. Assume that the flow rates start at $(0.7R, 0.01R)$. Assume there will be packet loss whenever the sum of flow rates crosses the link capacity R. Plot how the flows evolve over time for a large time horizon.



Run your simulations generating the above figures for two cases: (i) Both the flows have the same RTT; (ii) When one of the flows (say $f2$) has ten times larger RTT than the other.
What difference do you notice in the two cases? Does the system converge to the optimal/fair state? Measure the number of time steps (RTTs) required to converge to their respective fixed points (if they converge). The following values can be used: $R = 10000$, $SSTH = 0.04R$. You are also encouraged to try out different values for initial flow rates, R and $SSTH$ and report if you find any interesting observations. *[20 marks]*

Question 5: Network Resource Allocation as Utility Maximization

(**Optional**) Read sections 2.1-2.2 of the book 'Communication Networks: An Optimization, Control, and Stochastic Networks Perspective by R. Srikant and Lei Ying'. Formulate and solve the resource allocation problem in Example 2.2.1, posing as a utility maximization problem for various fairness measures listed below. Use the concept of Lagrange multipliers and KKT conditions used in Example 2.2.1, which can be studied from Section 2.1 of the book.

1. Proportional fairness
2. Minimum potential delay fairness
3. Sum-rate maximization fairness

END OF ASSIGNMENT