

Homework 1

Handed Out: October 3rd, 2023 Due: October 17th, 2023

- Homework assignments must be submitted online through **Blackboard**. Hard copies are not accepted. Please submit a **pdf file** to Blackboard. You can either type your solution or scan a legible hand-written copy. We will not correct anything we do not understand. Contact the TAs via email if you face technical difficulties in submitting the assignment.
- While we encourage discussion within and outside of the class, cheating and copying is strictly prohibited. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 100 points.
- **Please write your answer in the white space to the right of the corresponding problem.**

1 Choose all that Apply - 4 x 6 points

Each question may have more than one correct answer. You will only get points if you identify all the correct answers.

1. What devices can be considered as an end system in the network?

- (a) PC
- (b) wireless laptop
- (c) web server
- (d) mobile phone

2. Consider two hosts A and B transmit packets through three routers S_1, S_2, S_3 . Suppose the rates of the $A - S_1$, $S_1 - S_2$, $S_2 - S_3$, and $S_3 - B$ links are R_1, R_2, R_3 , and R_4 , respectively. Let $R_1 < R_2 < R_3 < R_4$. What should the throughput between A and B be?

- (a) R_1
- (b) R_2
- (c) R_3
- (d) R_4

3. Consider a router transmitting a packet of 15KB to another router on the same university campus, at a data rate of 10 Mbps. Assuming delay is expressed as $n \cdot 10^{-k}$ (seconds), where $1 \neq n < 10$, the value k for propagation delay is _ (choose from a to d). In this example, the statement that “total packet delivery time is dominated by the propagation delay time” is _ (choose from e and f).

- (a) 1
- (b) 2
- (c) 3
- (d) 4
- (e) false
- (f) true

4. Assume that the processing delay and queueing delay are 0. What is the total end-to-end delay of transmitting a packet?

- (a) Only transmission delay of all bits
- (b) Only propagation delay of the first bit
- (c) Propagation delay of the first bit, transmission delay of all bits and propagation delay of the last bit

- (d) Propagation delay of the first bit and transmission delay of all bits
- (e) Propagation delay of the last bit and transmission delay of all bits

5. Choose all the following statement(s) that is(are) correct about ' La/r ', where 'a' is the packet arrival rate, 'L' is the number of bits per packet, and 'r' is the router's service rate.

- (a) If average $La/r > 1$, no packet will be dropped at queue.
- (b) If average $La/r > 1$, no packet will be dropped at queue.
- (c) If average La/r decreases, average waiting time will decrease.
- (d) When La/r approaches to 0, the average waiting time will also approaches to 0.
- (e) When La/r increase and approaches 1, the average waiting time will increase linearly.

6. A network administrator tells you that at most 800 users can be accommodated by statistical multiplexing, given that each user needs 1 Mbps bandwidth and has a 20% chance of being active. This means, the total bandwidth is no less than _(choose from a and b). With TDM, 800 such users __ (choose from c and d) be accommodated.

- (a) 200
- (b) 160
- (c) might not
- (d) can surely

2 Probability and Throughput - 6 x 3 points

Suppose that 3 users are sharing a 300 Mbps connection. Each user uses the link 20% of the time. Assume their internet access activity is independent from each other and the network use is distributed uniformly.

1. What is the probability that no user is using the link simultaneous at the given time?

2. What is the probability that two users are using the link simultaneous at the given time?

3. Suppose that you want to use the link. Assume that when two or more people use the bandwidth are divided fairly among them. What is the average bandwidth you will receive?

3 Delays - 5 x 5 points

1. Explain the difference between transmission delay and propagation delay.
2. Suppose a router processes packets at the rate $R=1$ packet per second. Packets are arriving into the router's queue at time ticks (in seconds) shown in the table below. Compute (A) the average packet throughput in the first 10 seconds(B) the average queuing delay. Please only type in the final result in the text box. (Round your answer to 2 decimal places)

P0	P1	P2	P3	P4	P5	P6	P7	P8	P9
0	2	3	4	5	6	7	7	9	10

Average packet throughput:

Average queueing delay:

P0	P1	P2	P3	P4	P5	P6	P7	P8	P9
0	0	0	0	4	4	4	4	4	4

Average packet throughput:

Average queueing delay:

(For the following questions) Consider two hosts, A and B, that are connected by switch S. The link A-S is 100Mbps and has a propagation delay of 10ms. The link B-S is 80Mbps and has a propagation delay of 30ms. (1B = 8 bit, Assume 1KB = 1000B, 1MB = 1000KB)

3. Assume that no processing delay. If A sends a 1MB packet to B, what will the end-to-end delay be?
4. Suppose A sends 20 100KB packets to B continuously. Suppose S has a 500KB buffer for packets, will the packet be dropped?
5. Assume the buffer is infinite. A sends 100KB packets continuously. How long will it take for A to send 100MB. What is the average throughput?

4 Bandwidth, data rate and SNR- 5 + 3 + 5 points

Shannon's ground breaking equation says that: $C = B \log_2(1 + \text{SNR})$ where C is the data rate in bits/s achievable on the communication link (also called capacity), B is the bandwidth in Hz, and SNR is the ratio of received signal power to the receiver's noise power. Assume that the received signal power density $P \propto \frac{1}{R^2}$ where R is the distance between sender and receiver.

1. Suppose a laptop tends to transmit to a WIFI station located 10m away. Assume signal power density measured 2 meters from the laptop is $Q = 12\text{milliWatt}/m^2$ and the noise power density at the receiver is $N = 0.01\text{milliWatt}/m^2$. Suppose the laptop transmits at a bandwidth of 20MHz, what data rate can it achieve? (round your answer to 3 decimal places)

2. List at least two methods that can increase the data rate.
3. If the laptop intends to triple its data rate, how close should it move to the WiFi station? Assume all the other conditions are the same. (round your answer to 3 decimal places)

5 Internet concepts - 10 + 10 points

1. Mark all statements that are correct based on the classical principles of the network protocol stack: (-2pt per option wrong until 0)
 - (a) HTTP, SMTP, FTP are application layer protocols.
 - (b) All Internet components that have a network layer must run the IP protocol.
 - (c) The Transportation layer header can be read and modified by the router.
 - (d) The Network layer header can be read and modified by the router.
 - (e) Transport, Network, Link, and Physical layers are implemented at the core routers
 - (f) Suppose you send an email to your friend in another country, and your packets' link layer header does not contain your friend's link-layer address.
 - (g) Reducing the size of headers improves the goodput of the network
2. Briefly answer the following questions.
 - (a) List at least one advantage and disadvantage of protocol layering.
 - (b) Why will two ISPs at the same level of the hierarchy often peer with each other?
How does an IXP earn money?