

Introduction to Computer Networks

Fall 2021

Homework 1 (Due: 11/08/2021)

Name: _____

ID: _____

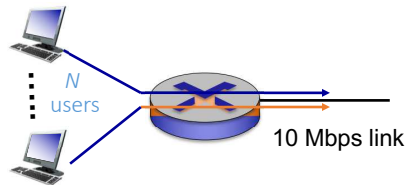
This homework contains 9 questions. The deadline is on Nov. 08 (Tue) at 23:59.
Please submit your answers to new E3.

1. (4 points) **Access Network:** ADSL stands for asymmetric DSL. (1) Please explain what does *asymmetric* mean. (2) Why does an ISP prefer to provide ADSL, instead of symmetric DSL?

2. (8 points) **Packet Loss:** (1) Please give two different root causes of packet losses. (2) In TCP, what mechanisms are designed to resolve the two issues?

3. (10 points) **Packet switching:** (1) Explain what is the difference of packet switching and circuit switching. (2) Explain what does *store and forward* mean. (3) Give two advantages and disadvantages of packet switching. (4) Explain why packet switching cannot provide performance guarantee.

4. (8 points) **Bandwidth sharing:** Consider the following scenario, where the outgoing link of the switch is 10 Mb/s and shared by users with packet switching. Assume that each user becomes active for only 10% of time and generates traffic of 500 Kb/s when it is active.



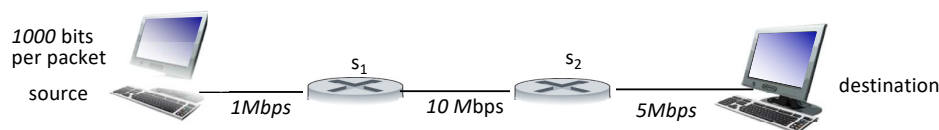
- (a) (4 points) If we want to make sure that each user can get a satisfactory service (i.e., rate no lower than 500 Kb/s) with a probability larger than 0.01, at most how many users (denoted by N) can join the system simultaneously? (**Note:** You only need to show your derivation (equation). No need to solve the final result.)

- (b) (4 points) If 1,000 users join the system and each is active for only 10% of time, then what is the probability that users CANNOT get a satisfactory service? (**Note:** You only need to show your derivation (equation). No need to solve the final result.)

5. (16 points) **Delay:**

- (a) (8 points) (1) List four different delay sources of the end-to-end delay and give a *formal definition* for each delay source. (2) Which types of delay sources are constant? (3) Which type of delay sources is typically hard to predict? Why?

- (b) (4 points) Consider the following scenario, where switches s_1 and s_2 only serve a single flow. Assume there is no propagation delay and nodal processing delay. If a packet of 1,000 bits is sent by the source at time $t = 0$, when does s_2 start to forward the packet? (Show your derivation and answer)



- (c) (4 points) Consider the same network. Assume that each switch has an infinitely large buffer. If the source now sends 10 back-to-back packets of length 1,000 bits time 0, what is the time that the destination receives all the 10 packets. (Show your derivation)

6. (16 points) **Application layer:**

- (a) (2 points) Explain what is the difference between *host-to-host* and *process-to-process* communications.

- (b) (4 points) How to distinguish different processes in the same host? What is the unique identity of a process?

- (c) (4 points) UDP is a connectionless and unreliable protocol. (1) Give an example application that uses UDP as the transport layer protocol. (2) Explain what kind of applications are suitable for using UDP.

- (d) (6 points) (1) Explain why proxy servers are *less popular* when we have CDN. (2) Assume each CDN server has a limited storage size. If you are the CDN operator, what is the strategy you would adopt to assign a subset of content objects to a CDN server. Why?

7. (10 points) **HTTP:**

- (a) (4 points) Explain what is the difference between persistent HTTP and non-persistent HTTP. Give the pros and cons of two mechanisms.

- (b) (6 points) (1) Consider an HTTP client that wants to retrieve a Web page including 3 images. Assume the Web server adopts *persistent HTTP*, which needs 1 RTT to build every TCP connection and 1 RTT to request for a content object. Suppose the server supports at most 2 parallel TCP connections. How many RTTs are required to download the entire Web page? (2) Now, suppose at most 4 parallel TCP connections are allowed. How many RTTs are required?

8. (12 points) **Reliable data transfer:**

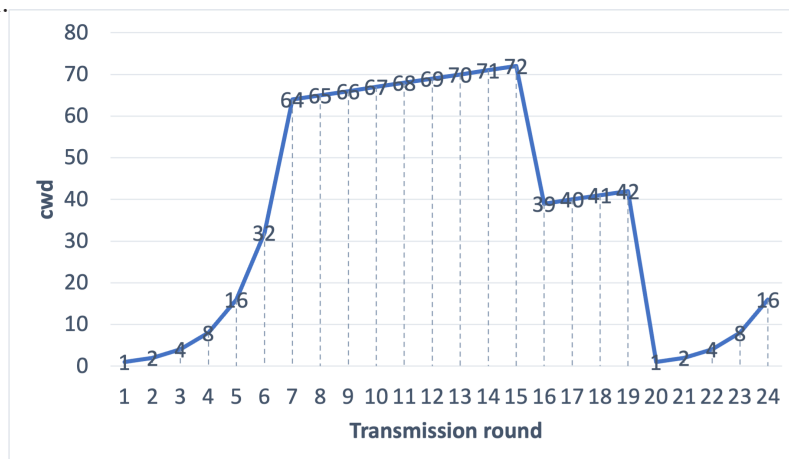
- (a) (5 points) (1) Explain what is the difference between bit errors and packet losses. (2) In rdt, what mechanism is used to resolve bit errors of a data packet? (3) In rdt, what mechanism is used to resolve bit errors of a feedback packet? (4) In rdt, what mechanism is used to resolve packet losses?

(b) (4 points) In the following cases, which cases could trigger unnecessary retransmissions? (multiple choices)

1. The sender receives a correct NACK from the receiver.
2. The sender misses the ACK from the receiver.
3. The sender receives the ACK from the receiver after the timeout.
4. The sender receives a corrupted ACK from the receiver.

(c) (3 points) Consider a path between a source and a destination with the bandwidth of 10Mb/s. Assume that 10% of data packets are lost. Assume that another 10% of the data packets are received correctly but their ACK cannot be sent back to the source by the timeout. Assume all the retransmissions can be successful. Then, what is the final throughput?

9. (16 points) **TCP congestion control:** Consider the following figure. Assuming TCP Reno is the protocol.



(a) (4 points) Explain what is the *design goal* of slow start and congestion avoidance, respectively.

- (b) (4 points) Identify the intervals of time when TCP slow start is operating.

- (c) (4 points) Identify the intervals of time when TCP congestion avoidance is operating.

- (d) (4 points) What is the initial value of `ssthresh` at the 5th and 18th transmission round, respectively?