Introduction to Computer Networks **Name:** _____
Fall 2020
Homework 1 (Due: 11/01/2020) **ID:** _____

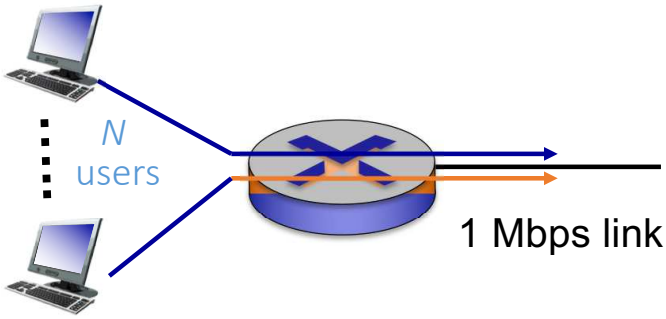
This homework contains 10 questions. The deadline is on Nov. 01 (Sun) at 23:59. Please submit your answers to new E3.

1. (5 points) **Access Network:** Give the full name of ADSL. Explain what does *asymmetric* mean.

2. (5 points) **Access Network:** The key difference between WLANs and cellular networks is that the former operates over *unlicensed band*, while the later operates over *licensed band*. Explain what is *licensed band*.

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) What is the benefit of exploiting *store and forward*? (4) Give two advantages and disadvantages of packet switching.

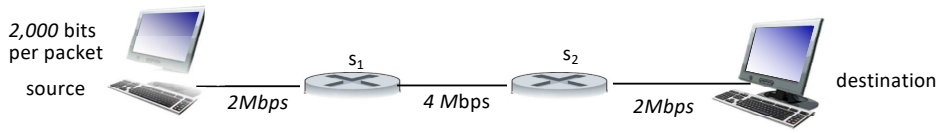
4. (10 points) **Packet switching:** Consider the following scenario, where the outgoing link of the switch is 1 Mb/s. Assume that each user becomes active for only 10% of time and generates traffic of 100 kb/s when it is active. If we want to make sure that each user can get a satisfactory service (i.e., rate no lower than 100 kb/s) with a probability larger than 0.001, at most how many users can join the system simultaneously? (Show your derivation)



5. (15 points) **Delay:**

   (a) (5 points) Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

   (b) (5 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 2,000 bits is sent by the source at time $t = 0$, when does s_2 start to forward the packet? (Show your derivation)



   (c) (5 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 2,000 bytes at time 0, what is the time that the destination receives all the 5 packets. (Show your derivation)

6. (15 points) **Application layer:**

   (a) (3 points) Explain what is the difference between *host-to-host* and *process-to-process* communications.

   (b) (3 points) How to distinguish different processes in the same host? What is the unique identity of a process?

   (c) (3 points) Suppose you wanted to do a transaction from a remote client to a server as fast as possible. Would you use UDP or TCP? Why?

   (d) (6 points) Define what is a *distributed* system. Define what is a *hierarchical* system. Give one advantage of a *distributed* system. Give one advantage of a *hierarchical* system.

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

   (a) (3 points) Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?

(b) (3 points) Explain what is the difference between persistent HTTP and non-persistent HTTP. Which one spends more handshaking latency?

(c) (4 points) Define what is RTT. Consider an HTTP client that wants to retrieve a Web page including 5 images. Assume the Web server adopts non-persistent HTTP, which needs 2 RTT to build every TCP connection, and support at most 100 parallel TCP connections. How many RTTs are required to download the entire Web page?

8. (10 points) **Video streaming:**

(a) (4 points) Explain what is the difference between video-on-demand and real-time video streaming. Typically, which one consumes more bandwidth? Why?

(b) (6 points) (1) Explain what does *auto-rate (adaptation)* in DASH (HTTP streaming) mean. (2) Explain why dividing a video into multiple chunks is beneficial for auto-rate? (3) Consider two network scenarios, one with stable bandwidth and the other with fluctuated bandwidth. Which scenario is more challenging for auto-rate adaptation? Why?

9. (10 points) **Reliable data transfer:**

   (a) (3 points) Explain what is the difference between error detection and error recovery. Check sum is an error detection algorithm or error recovery algorithm?

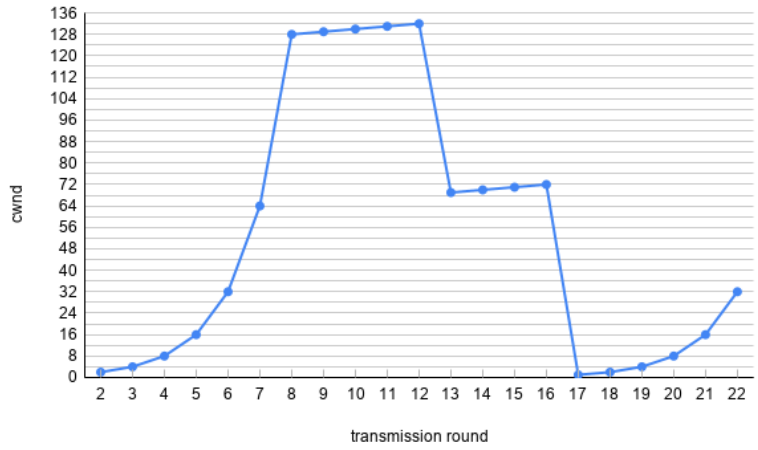
   (b) (2 points) In the following cases, which cases could trigger unnecessary retransmissions? (multiple choices)

      1. The sender sends a packet and sets a timeout to 1ms, while the receiver does not receive any packet.
      2. The sender receives a corrupted feedback from the receiver.
      3. The sender sets a timeout shorter than RTT.
      4. The sender receives a corrected ACK from the receiver.

   (c) (2 points) In rdt, how does a sender act if it receives a corrupted feedback?

   (d) (3 points) In rdt, timeout is used to deal with packet losses. Explain in which case retransmissions due to timeout may be unnecessary. How to avoid this issue?

10. (10 points) **TCP congestion control:** Consider the following figure. Assuming TCP Reno is the protocol.



(a) (3 points) Identify the intervals of time when TCP slow start is operating.

(b) (3 points) Identify the intervals of time when TCP congestion avoidance is operating.

(c) (4 points) What is the initial value of `ssthresh` at the 7th and 15th transmission round, respectively?