COE 431 – Computer Networks

Welcome to Exam II
Thursday April 21, 2016

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Name: ______________________

Student ID: ________________

Instructions:

1. This exam is **Closed Book**. Please do not forget to write your name and ID on the first page.
2. You have exactly **85 minutes** to complete the **6** required problems.
3. Read each problem carefully. If something appears ambiguous, please write your assumptions.
4. Do not get bogged-down on any one problem, you will have to work fast to complete this exam.
5. Put your answers in the space provided only. No other spaces will be graded or even looked at.

Good Luck!!

<u>Problem I:</u> Multiple choice questions (**10 minutes**) [10 Points]

1. Which of the following is/are true?
   I. The presentation layer manages synchronization of data exchange
   II. The session layer is concerned with data compression and data encryption
   a. I only
   b. II only
   c. I and II
   d. **None of the above**

2. Assuming infinite link bitrate, and infinite signal propagation speed, delays would still be observed in a packet switched network due to:
   a. Processing and transmission delays
   b. Queueing and propagation delays
   c. Processing and propagation delays
   d. **None of the above**

3. When using packet switching with 32 users, what is the probability that more than 10 users are active at the same time, if each user is independently active 18% of the time?
   a. 0.01
   b. 0.03
   c. **0.02**
   d. None of the above

The code fragment below is taken from a Java implementation of a connectionless client:

```
String line = inFromUser.readLine();
InetAddress IPAddress = InetAddress.AAA("localhost");
byte[] sendData = line.BBB();
```

4. In the code above, **AAA** should be?
   a. `getInetAddress`
   b. `getAddress`
   c. `getIPAddress`
   d. **None of the above**

5. In the code above, **BBB** should be?
   a. `bytes`
   b. `getbytes`
   c. `readBytes`
   d. **None of the above**

6. The lower X layers in the Internet protocol stack are implemented in the following network devices: switches, routers, and end systems? X=
    a. 1
    b. **2**
    c. 3
    d. None of the above

7. Host A sends to Host B a TCP segment (Sequence nb. = 43, Acknowledgment nb. = 103), to which Host B responds with a TCP segment (Sequence nb = 103, Acknolwedgment nb. = 57). How long is the payload of the first TCP segment?
    a. 60 bytes
    b. 13 bytes
    c. 47 bytes
    d. **None of the above**

8. Consider a TCP connection between two Hosts A and B. Suppose Host A sends two segments to Host B. Host B then sends an acknowledgment for each segment. If the first acknowledgement is lost but the second acknowledgment arrives at A before the timer for the first segment expires, then
    a. Host A will retransmit both the first and the second segments
    b. **Host A will retransmit neither of the segments**
    c. Host A will retransmit the first segment only
    d. None of the above

9. MSS represents
    a. The maximum size for a TCP segment
    b. **The maximum amount of application layer data for a TCP segment**
    c. The maximum size for a data link layer payload
    d. None of the above

10. Which of the following bodies does not deal with network standardization?
    a. ISO
    b. ITU
    c. IEEE
    d. **None of the above**

<u>Problem II:</u> Comparing terminologies (**10 minutes**) [10 Points]

What is the difference between each of the following pairs of concepts?

1. TCP connection establishment and TCP connection release

TCP connection establishment is also known as the three way handshake and it involves the exchange of 3 control segments between a TCP sender and a TCP receiver. It takes between 3 to 4 control segments to close a TCP connection.

2. BitTorrent and DHT

BitTorrent is a peer-to-peer file distribution protocol. DHT on the other hand uses hash tables to implement a distributed database in a P2P network.

3. PSH and URG flags in the header of a TCP segment

PSH indicates that the receiver should pass the data present in the payload of a TCP segment immediately to the upper layer. URF is used to indicate that there is data that the sending side has marked as urgent.

4. Overlay network and underlay network

In an overlay network, the peers form an abstract logical network which resides above the underlay network consisting of physical links, routers and hosts. Links in an overlay network are TCP connections.

5. EstimatedRTT and DevRTT

EstimatedRTT is the best current estimate of RTT at a TCP sender. DevRTT is a measure of the variability of RTT.

Problem III: Pipelining (**15 minutes**) [20 Points]

Consider two hosts A and B that are interconnected through a 1 Mbps link and that are separated by an RTT = 24 ms. Assume that A wants to send 6 packets of length 1500 bytes each to B. Suppose also that each ACK message generated by B in response to the receipt of a packet from A has a negligible size.

1. What is the average utilization of the sender A if a stop-and-wait protocol is employed? What is the effective throughput? **Show your work**

$$Average\ utilization = \frac{6 \times \frac{L}{R}}{6 \times \frac{L}{R} + 6 \times RTT} = \frac{0.012}{0.012 + 0.024} = 33.333\%$$

⇨ Effective throughput = 33.333% × 1 Mbps = 333.33 Kbps

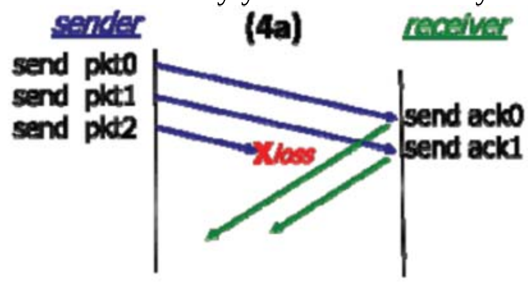
2. What is the average utilization of the sender A if a pipelined protocol is used with a pipeline size equal to 3 (i.e., the pipeline can be filled up with up to 3 packets)? What is the effective throughput in this case? **Show your work** (Assume that all 3 ACKs sent by B back to A arrive to A at the same time)

$$Average\ utilization = \frac{6 \times \frac{L}{R}}{6 \times \frac{L}{R} + 2 \times RTT} = \frac{0.036}{0.036 + 0.024} = 60\%$$

⇨ Effective throughput = 60% × 1 Mbps = 600 Kbps

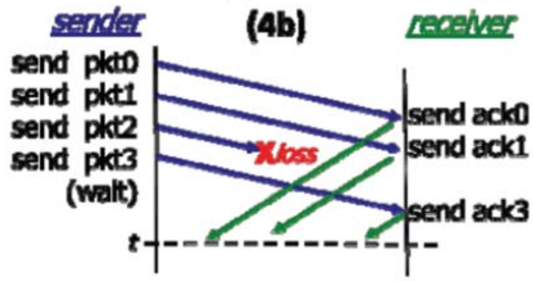
Problem IV: Sliding Window Protocols (**15 minutes**) [15 Points]

1. Consider the sliding window protocol in the figure below. Does this figure indicate that Go-Back-N is being used, Selective Repeat is being used, or there is not enough information to tell? Justify your answer briefly.



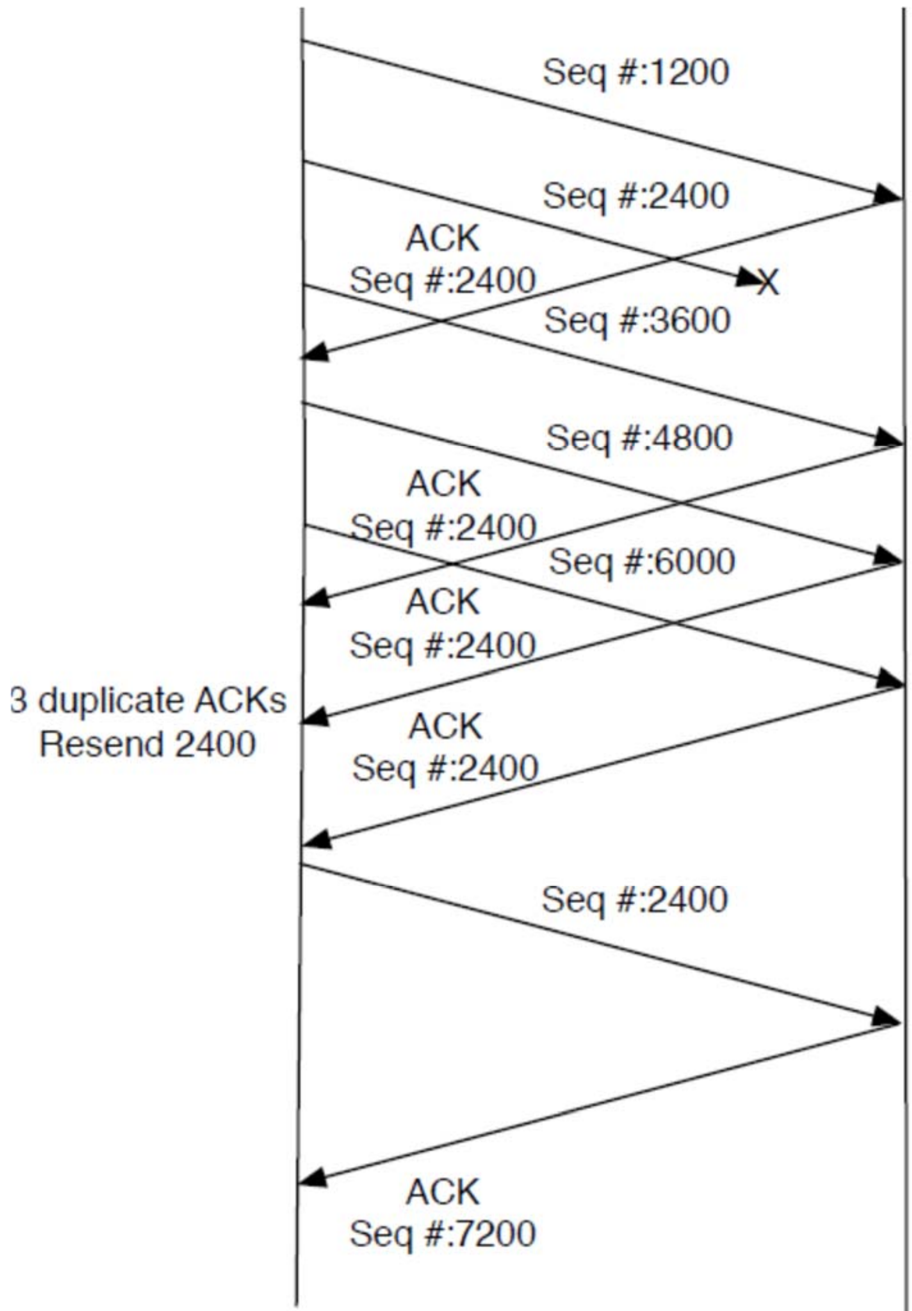
There is not information to tell since both GBN and SR will individually ACK each of the first 2 messages as they are received correctly.

2. Consider the sliding window protocol given in the figure below. Does this figure indicate that Go-Back-N is being used, Selective Repeat is being used, or there is not enough information to tell? Justify your answer briefly.



This must be a SR since pkt 3 is ACKed even though pkt2 was lost. GBN uses cumulative ACKs and so would not generate an ACK3 if pkt2 was missing.

3. Assume a TCP sender transmits 5 TCP segments with respective sequence numbers of 1200, 2400, 3600, 4800, and 6000. The sender receives five acknowledgments with acknowledgment numbers of 2400, 2400, 2400, 2400, and 7200. Complete the Figure below to show the TCP segments exchanged between sender and receiver. Label the segments generated by the sender with sequence numbers and the ones generated by receiver with the acknowledgment numbers.

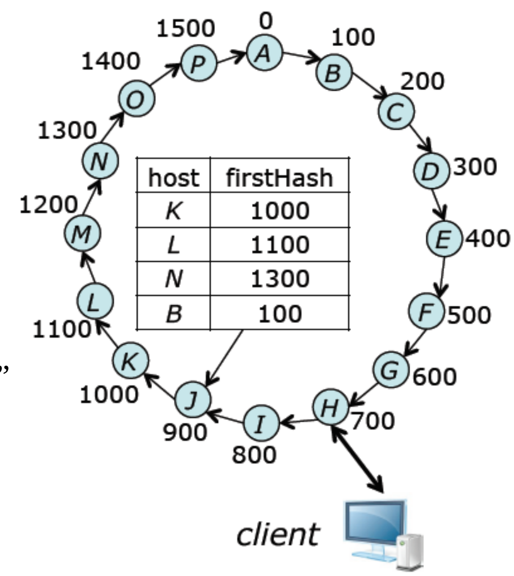


<u>Problem V:</u> Peer to Peer Networks (**15 minutes**) [20 Points]

1. Consider distributing a file of size *F*=15 GBits to *N*= 4 peers. The server has an upload rate of u_s = 30 Mbps, and the peers have download rates of d_1 = 1 Mbps, d_2 = 2 Mbps, d_3 = 3 Mbps, d_4 = 4 Mbps respectively. Assume that all 4 peers have an individual upload rate of u = 3 Mbps. Compute the minimum file distribution time for client-server and P2P architectures.

Dcs = 15000 sec; DP2P = 15000 sec.

2. The diagram at right shows a DHT with 16 nodes. Each node is labeled with the first value in its range of values (so for example, B is responsible for hash values 100-199). The routing table for node J is shown in the figure. Note that J has routes to the node that is 1 hop away, the one that is 2 hops away, the one that is 4 hops away and the one that is 8 hops away. Assume that all nodes have routing tables that are configured similarly.
   Suppose the client shown in the diagram sends a get request to node H with a key string of "network love" and that *hash*("network love") = 1330. List the servers through which this request would pass assuming that the key string is already cached in M's cache?
   H, L, M



What servers would the request above pass through if the key string is already cached in node I's cache?

H, L, M, N (if M does not have a copy of the file)

<u>Problem VI:</u> TCP (**20 minutes**) [25 Points]

Consider a single TCP Reno connection that uses one 10 Mbps link to connect a sending host to a receiving host. Assume that the TCP sender has a huge file to send to the receiver and that the receiver's receive buffer is much larger than the congestion window. The following assumptions are also made: a) MSS = 1500 bytes; b) RTT = 100 ms; and c) this TCP connection is always in a congestion avoidance phase with the congestion window varying between W/2 and W (which is the maximum window size reached when the sending rate matches the link capacity, as in this case a packet is dropped and the congestion window goes back to W/2).

1. What is the maximum congestion window size (in segments) that this TCP connection can achieve? **Show your work.**

Let W denote the max window size measured in segments. Then, W*MSS/RTT = 10Mbps, as packets will be dropped if the maximum sending rate exceeds link capacity. Thus, we have W*1500*8/0.1=10*10^6, then W is about 84 (ceiling of 83.3) segments.

2. What is the average window size (in segments) and average throughput of this TCP connection? **Show your work.**

As congestion window size varies from W/2 to W, then the average window size is 0.75W=63 segments. Average throughput is 63*1500*8/0.1=7.56Mbps.

3. How long would it take for this TCP connection to reach its maximum congestion window value again after recovering from a segment loss? **Show your work.**

84/2 *0.1= 4.2 seconds, as the number of RTTs (that this TCP connections needs in order to increase its window size from W/2 to W) is given by W/2. Recall the window size increases by one in each RTT.

4. Suppose now that the 10 Mbps link is replaced with a 10 Gbps link. If the objective is to achieve a throughput of 10 Gbps through this TCP connection, what segment loss probability can be tolerated? **Show your work.**

Loss rate = 0.214×10^{-9}