COE 431 – Computer Networks

Welcome to Exam II
Thursday April 30, 2015

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Name: _____Solution Key_____

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 **80 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!!

Problem I: Multiple choice questions (**10 minutes**) [10 Points]

1. Network protocols define the:
   I. format and order of messages sent and received
   II. actions taken on message transmission and receipt
   a. I only
   b. II only
   c. **I and II**
   d. None of the above

2. Which of the following is/are true?
   I. PAN is professional-area network
   II. Bluetooth is an example of a PAN
   a. I only
   b. **II only**
   c. I and II
   d. None of the above

3. The Internet protocol stack includes X layers, while the OSI architecture includes Y layers.
   a. X=7, Y=4
   b. **X=5, Y=7**
   c. X=7, Y=5
   d. None of the above

4. In the Internet protocol stack, the following two OSI layers are missing
   a. Physical and Session
   b. Presentation and Data Link
   c. Transport and Session
   d. **None of the above**

5. In a 5-layer network architecture, an application generates a 100 Byte message. Layer 4, 3, and 2 add a 20-Byte header each. Layer 2 adds a 4-Byte trailer. How many bits are actually transmitted as a result of the message, as seen “on the wire”?
   a. **1312**
   b. 1400
   c. 1600
   d. None of the above

6. A circuit-switched link uses TDM to support 48 simultaneous users. Each user is allowed to transmit 200 bits during a timeframe of 100 μs. What is the overall bitrate of the link in Mbps?
    a. 2
    b. 24
    c. **96**
    d. None of the above

7. When using packet switching with 32 users, what is the probability that more than 10 users are active at the same time instant, if each user is independently active 18% of the time?
    a. 0.01
    b. **0.02**
    c. 0.04
    d. 0.05

8. An Ethernet frame includes 1000 Bytes of payload, 22 Bytes of header, and 4 Bytes of trailer. Find the transmission time (in μs) of this frame over a 100 Mbps interface?
    a. **82.1**
    b. 80.0
    c. 85.6
    d. 93.4

9. The frame in the previous problem is sent over a cable 100 meters long. Find the propagation delay (in μs) over this cable if the signal propagation delay is 2×10^8?
    a. 0.3
    b. 0.4
    c. **0.5**
    d. None of the above

10. Find the total time needed to send a 1 million Byte file from host A to host B, over a 1 Gbps, 200 Km fiber link. The total time includes a setup time (one RTT) and the time to continuously transmit 1 million Bytes. The signal propagation speed is 2×10^8.
    a. 7
    b. 8
    c. 9
    d. **None of the above**

Problem II: Comparing terminologies (**10 minutes**) [10 Points]

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

1. Time-out driven retransmission and fast retransmit

With time-out driven retransmission, the sender waits until the timer expires before retransmitting a packet. However, with fast retransmit, the sender waits until the same packet gets acknowledged three times before performing a fast retransmit of the said packet.

2. GoBack-N pipelined error recovery and TCP error recovery

Some implementation of TCP might buffer correctly received out-of-order packets while with GoBack-N, out-of-order packets are discarded at the receiver.

3. RST and SYN in the header of a TCP segment

The SYN flag is set to one during the connection setup phase. However, the RST bit is set to one by the receiver when no application is listening to the destination port number specified by the SYN segment.

4. Sequence number and Acknowledgment number in a TCP segment

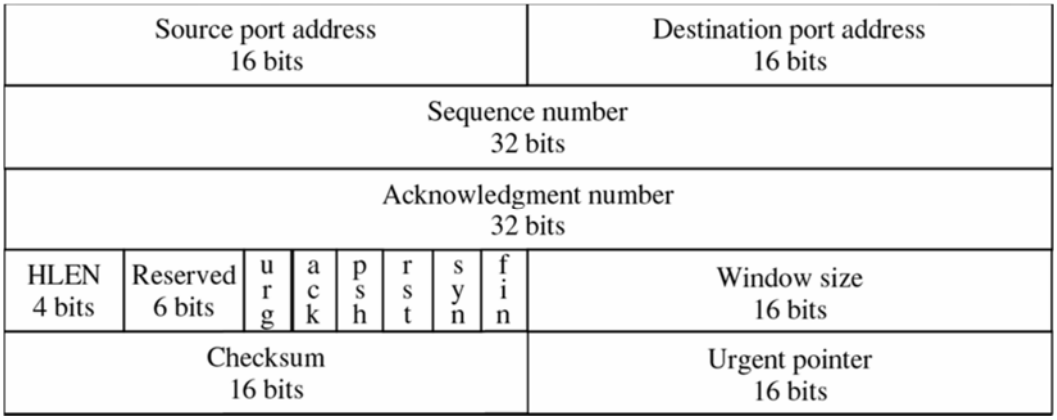
The acknowledgement number is the number of the next in-order byte the receiver expects to receive from the sender. However, the sequence number is the number corresponding to the first byte in the TCP segment.

5. Full mesh and circular overlay topologies in DHT

In a full mesh topology, each peer is connected to every other peer. On the other hand, in a circular topology, peers are organized into a circular overlay topology.

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

TCP is used to transfer a 511 KiloBytes (KB) file from Host A to Host B over a 10 Mbps link with an RTT of 100 ms. Assume that the `Threshold` variable maintained by TCP is equal to 64 KB and that TCP sends segments with an MSS of 1 KB. The 20 bytes long TCP header is given below (we ignore the optional part of the header in this problem):



1. The TCP protocol is said to provide a connection-oriented reliable in-order stream service with flow control and congestion control, which fields in the TCP header are needed for each of the following characteristics of the TCP protocol:
    a. Connection-oriented: **ack, syn, fin, rst**
    b. Reliable in-order delivery: **sequence number, ack number, ack flag**
    c. Flow control: **window size**
2. How many RTTs does it take until the slow start phase of TCP increases the send window to 64 KB? Assume that the initial value of the window is set to 1 MSS? Justify your answer.

It takes 6 RTTs.

3. How many RTTs does it take the TCP protocol considered in this problem to send the entire file? Show your work.

During the first 6 RTTs, 64 KB are sent including headers. The data that has been sent is: 511 KB-63KB+0.126KB = L
S = # of segments required = L/(1 KB – 20 B) = 457.05 segments =>
# of RTTs = S/48 = 8 RTTs => Total number of RTTs = 8 + 6 = 14 RTTs

4. If the time to send the file is given by the number of required RTTs computed in (3), what is the effective throughput for the transfer? And what percentage of the link bandwidth is being utilized?

T=511 KB/(# of RTTs * 100) = 373, 360 bps
% = 0.373/10 * 100 = 37.3 %

Problem IV: Segmentation and UDP (**15 minutes**) [20 Points]

Assume Host A needs to transfer voice data of 1000 Bytes to Host B using an application layer protocol that runs over UDP over IP over Ethernet. For each voice message, the UDP protocol adds a header of length 8 bytes, the IP protocol adds a header of length 20 bytes, and the Ethernet protocol adds a header of length 24 bytes. The distance between Host A and Host B is 9 Km and the propagation speed is 3×10^8 m/s. Assume that Host A and Host B are separated by two equidistant switches and that all links are 1 Gbps Ethernet links. Moreover, assume that the processing delay per frame at each switch is 1 μs and that switches apply the store-and-forward switching paradigm.

1. Assume Host A sends the whole voice data to Host B as one message. Calculate the total time needed to transfer the whole voice data from Host A to Host B. Show your steps.

The header is 52 Bytes. The data is 1000 Bytes. Message + header = 1052 Bytes.
Transmission delay = 8.4 μs. Propagation delay = 30 μs => Total propagation delay = 57.2 μs

2. Assume now that the application layer protocol divides the voice data into **two** equal-size messages that are sent directly one after the other. Calculate the total amount of time needed to send all the voice data from Host A to Host B. Show your steps clearly.

The header is still 52 Bytes. The data in each message is 500 Bytes. Message + header = 552 Bytes.
Transmission delay = 4.5 μs. Propagation = 10 μs. Total = 30 μs

3. Based on your findings in the previous two parts, list one advantage and one disadvantage of data segmentation.

Advantage: more efficient. Disadvantage: more complex, more overhead.

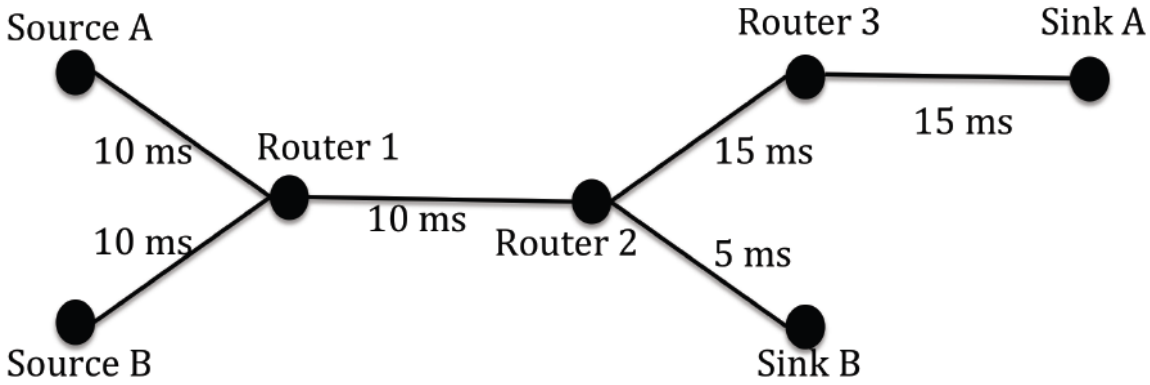
4. Assume the voice data needs to be sent reliably, how can this be done knowing that UDP is used as the transport layer protocol?

We could add reliability functionality at the application layer level. This could be done in the application layer headers.

Problem V: TCP congestion control (**15 minutes**) [25 Points]

Note: in this problem, please show as much of your work as you can. Even if you get a wrong answer, you can get partial credit if you show your work. If you make a mistake, it will help me identify where you made a mistake.

For this problem, you should familiarize yourself with the figure given below.



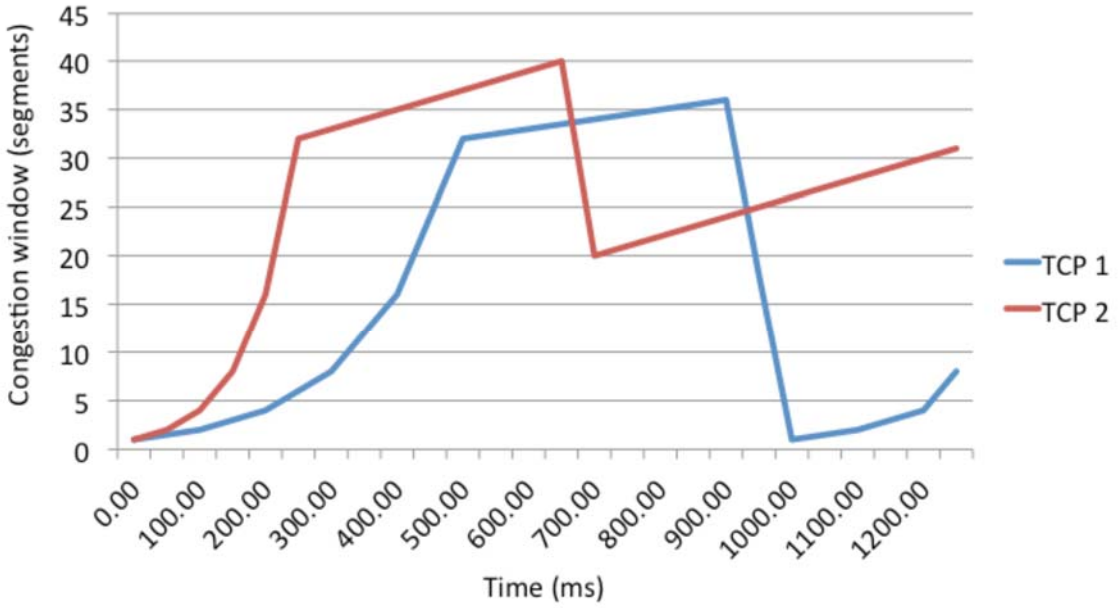
Assume that in the network shown above two parallel TCP transmissions are taking place. TCP1 is a transmission between Source A and Sink A that uses TCP Tahoe. TCP2 is a transmission between Source B and Sink B using TCP Reno. Initial `Threshold` value for both TCP transmissions is set to 32. In this specific scenario no additional delay through forwarding is introduced. So, the RTT is only composed of the sums of the delays indicated on each link, times two.

1. For the TCP1 transmission, draw on the chart given on the next page the resulting congestion window, assuming that a packet loss (triple duplicate ACKs) is detected at time = 900 ms.
2. For the TCP2 transmission, draw the resulting congestion window on the same chart as before, assuming that a packet loss is detected at time t=650 ms.
3. Describe the benefit of TCP Reno over TCP Tahoe

Benefit: fast retransmit.

4. In general, explain the purpose of the receiver-advertised window in TCP.

Flow control


Congestion window (segments)
45
40
35
30
25
20
15
10
5
0
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.00
1100.00
1200.00
Time (ms)
TCP 1
TCP 2

Problem VI: Peer to Peer Networks (**15 minutes**) [15 Points]

1. Consider distributing a file of size F=700 MBytes to N=10000 peers. The server has an upload rate of u_s = 100 Mbps, and each peer has a download rate of d = 5 Mbps and an upload rate of u = 300 Kbps. Compute the minimum distribution time for client-server and P2P architectures. Assume that 1 Mbps = 1000 Kbps = 1000 000 bps and that 1 MByte = 1024 KBytes = $(1024)^2$ Bytes.

For calculating the minimum distribution time for client-server distribution, we use the following formula: Dcs = max{NF/us, F/dmin} = 163h 6min 43 s
Similarly, for computing the minimum distribution time for P2P distribution, we use the following formula: D_{P2P} = max{F/us, F/dmin, NF/(us + sum(ui))} = 5 h 15 min 42 s.

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 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 "flapjack" and that *hash*("flapjack") = 513. List below the nodes through which this request would pass.

It would go through nodes P, D, and F before returning to H and then the client.