Instructions

This exam is close-book, close-notes, and close-Internet. You are allowed to use a calculator. You have 75 minutes to complete the exam and must upload your exam papers to Canvas by April 1st, 2021, 12:15PM.

You are required to write out and sign the honor pledges below.

Honor Pledges

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

Your signature:

CISC450/CPEG419: Computer Networks I
Midterm Exam
April 1st, 2021 11:00AM-12:15PM

Name: **UD ID:** **Grade in Points:**

True or False (3 points each)

1. With persistent connections between browser and web server, it is possible for a single TCP segment to carry two distinct HTTP request messages. ( )

2. It is possible that the data being read from a server-side TCP socket were sent by more than one clients. ( )

3. Suppose that we want to change the IP address of `www.cis.udel.edu` from 23.185.0.3 to 23.185.2.15 and change this mapping in the DNS authoritative name server for `www.cis.udel.edu`. As soon as this mapping is changed in the authoritative name server, all future references (generated anywhere in the Internet) to `www.cis.udel.edu` will then be sent to 23.185.2.15. ( )

4. With the Go-Back-N protocol, it is impossible for the sender to receive an ACK for a packet that outside of its current window. ( )

5. Assume that host A needs to send a sequence of packets to host B, and each packet needs to traverse three links with bandwidth 1 Mbps, 4 Mbps, and 4 Mbps, respectively. The end-to-end throughput between A and B is (1+4+4)/3=3 Mbps. ( )

Multiple Choices Single Answer (5 points each)

6. Consider a TCP connection between host A and host B. Suppose that TCP segments traveling from host A to host B have source port number x and destination port number y. Which of the following statement is correct about the segments traveling from B to A? ( )

- (A) The source port number is x, and the destination port number is y.
- (B) The source port number is y, and the destination port number is x.
- (C) The destination port number is x, and host B can choose arbitrate source port number.
- (D) Host B can choose arbitrate source port number and destination port number.

7. When a browser sends a DNS query, a sequence of DNS servers will be contacted in order. Which of the following sequences of DNS servers cannot happen in reality? ( )

- (A) Local DNS server$\rightarrow$ root DNS server $\rightarrow$ TLD DNS server $\rightarrow$ authoritative DNS server
- (B) Local DNS server$\rightarrow$ TLD DNS server $\rightarrow$ authoritative DNS server
- (C) Local DNS server$\rightarrow$ authoritative DNS server $\rightarrow$ TLD DNS server
- (D) Local DNS server

8. How many round trips would it take to download a web page that contains N embedded small objects under nonpersistent HTTP with K parallel TCP connections?

- (A) $2 \times N$
- (B) $2 \times (N + 1)$
- (C) $2 \times (\lceil N/K \rceil)$ ($\lceil \cdot \rceil$ denotes the ceiling operation, e.g., $\lceil 2.5 \rceil = 3$)
- (D) $2 \times (\lceil N/K \rceil + 1)$

9. Consider a link with transmission rate R. Assume that N packets of size L arrive to the link every LN/R seconds. Which of the following cannot be the average queueing delay? ( )

- (A) 0
- (B) $\frac{N(N-1)R}{4L}$
- (C) $\frac{N(N-1)R}{2L}$
- (D) $\frac{3N(N-1)R}{4L}$

10. Suppose that two hosts A and B are separated by 500,000 kilometers and are connected by a direct link of $R = 2$ Mbps. Also suppose that the propagation speed over the link is 2.5×10^8 meter/sec. Assume that A sends B a file of 5×10^6 bits as a large message. What is the maximum number of bits in the link that will be in the link at any given time ( )

- (A) 1×10^6
- (B) 2×10^6
- (C) 4×10^6
- (D) 5×10^6

Problem 11 [20 Points]: Consider an institutional network connected to the Internet. The institutional network has a speed of 1 Gbps. The access link between the institutional router and the Internet router is 20 Mbps. Suppose that the average object size is 150K bytes and that the average request rate from the institution's browsers to the origin web servers is 16 requests/second. Also suppose that **average Internet delay** is three seconds (the Internet delay is the amount of time it takes from when the router on the Internet side of the access link forwards an HTTP request until it receives the response). For the **average access delay** (i.e. the delay from Internet router to institution router), use $A/(1 - AB)$, where A is the average time required to send an object over the access link and B is the arrival rate of objects to the access link. Model the **total average response time** as the **sum** of the *average access delay* and the *average Internet delay*.

- (a) Without a cache, what is the average access delay and what is the total average response time? [10 Points]

- (b) Now suppose a cache is installed in the institutional LAN. Suppose the miss rate is 0.4. What is the average access delay and what is the total average response time? Note in this case, the Internet delay is incurred only when a requested page is not in the cache. [10 Points]

Problem 12 [20 Points]: Suppose that 15 users share a 2 Mbps link where packet switching is used. Also suppose that each user alternates between periods of activity, when a user generates data at a constant rate of 250 kbps, and periods of inactivity, where a user generates no data. Suppose further that a user is active only 15 percent of the time.

- (a) What is the probability that at any given time, exactly 2 users are transmitting? [10 Points]

- (b) What is the probability that there are no more than 8 users transmitting simultaneously. [10 Points]

Problem 13 [20 Points]: A 4-Mbps satellite link with 499 ms one-way propagation delay is used to transmit data packets of 1000 bytes. Both the header of the data packets and the acknowledgment packets are of negligible size. What is the minimal number of bits needed for sequence numbers to achieve a link utilization of 50% under

- (a) A Go-back-N protocol [10 Points]

- (b) A selective repeat protocol [10 Points]

Bonus Problem [10 Points]: Consider sending a large file of F bits from Host A to Host B. There are n links (and $n-1$ switches) between A and B, and the links are uncongested, i.e., no queueing delays. Host A segments the file into segments of s bits and adds h bits of header to each segment, forming packets of $L = s + h$ bits. Each link has a transmission rate of R bps. Find the value of s that minimizes the delay of moving file from Host A to Host B. Disregard propagation delay.