Student Name: _____

Professor Zheng Song Mid-term Exam, CIS 427, UMDearborn Oct 20, 2022

1. This is an OPEN book exam that takes 1 hour and 45 minutes. You may use any available resources offline and online, but you are NOT allowed to seek help from others or help others. You are not allowed to contact anyone by any form during the exam. All violations will be reported to the University's academic integrity board.

2. The exam has 10 multi-choice questions, 10 T/F questions, and 4 short answers. Please make good use of your time.

3. When handwriting the exam, please leave adequate space on the left and right margins for comments and points, and use a pen with blue or black ink. For calculation questions, your points will be given based on both your results and your calculation steps.

4. By participating in the exam and turning in your answer, you certify that you have neither received nor given any aid beyond the allowed use of materials.

5. For simplicity, 1,000 bytes = 1KB, 1,000,000 bytes = 1MB, 1byte = 8 bits

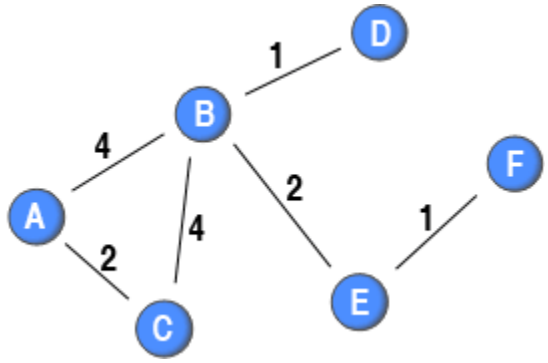
This exam consists of **7 pages**, including this cover page. Please be sure your exam is complete. Please be sure that you write your name on the cover page.

1. Multiple Choice Questions (30 points = 10 questions * 3 points each)

[B] 1) The network layer communicates with the following two layers:

A. TCP layer and UDP layer
B. Link layer and Transport layer
C. Communication layer and data layer
D. Application layer and physical layer

[C] 2) For a network system shown in Fig.1, the numbers on links denote the bandwidth of the links. What is the maximum end-to-end bandwidth between node A and node F:



A. 5 B. 7 C. 1 D. 8

[C] 3) Which of the following sources of delay in the Internet depends on traffic from other applications and hosts that are not on the path of a connection?

A. Propagation delay.
B. Transmission delay.
C. Queuing delay.
D. Packetization delay.

[C] 4) Which statement about DNS is true:

A. DNS is TCP-based for ensuring reliability
B. All DNS requests are first sent to a local DNS server
C. DNS translates IP addresses to domain names
D. Only one DNS result can be included in a DNS response message.

[B] 5) Assume a one-dimensional even parity check is used during data transmission. The following data is received, which contains 7 bits of data and 1 bit of parity code. Which of the following data has an error?

A. 11110110 B. 10100100 C. 01100101 D. 10000001

[C] 6) Which of the following control fields in the TCP header is used to specify the request to tear down a connection?

A. ACK B. PUSH C. FIN D. SIN

[D] 7) Suppose a client just sent two segments of 1000 bytes each over a new established TCP connection to the same server, and then received an ACK number of 10001. Which of the

following **cannot** be the sequence number of the first segment sent by the client?

A. 10001 B. 9001 C. 8001 D. 11001

[B] 8) RWND parameter is taken from

A. Sender's TCP header B. Receiver's TCP header C. Not in TCP header

[D] 9) On a TCP connection with MSS=2KB, the current congestion window size is 6 KB (cwnd) and the window size advertised by the receiver is 4 KB (rwnd). If all previous segments have been ACKed, how many segments can the sender send in this round of transmission?

A. 10 B. 2000 C. 4 D. 2

[C] 10) Classless Inter-domain Routing (CIDR) receives a packet with address 131.20.126.59. Given the following routing table of the router, the identifier of the output interface on which this packet will be forwarded is ___

Prefix	Output Interface Identifier
131.16.0.0/12	3
131.28.0.0/14	5
131.19.0.0/16	2
131.22.0.0/15	1

A. 1 B. 2 C. 3 D. 5

2. T/F Questions (20 points = 10 questions * 2 points each)

[T] 1) Compared with circuit switching networks, packet switching networks can host more users with the same bandwidth, at the cost of possible collisions.

[F] 2) The layered network model reduces the overhead of data transmission.

[F] 3) TCP guarantees throughput and UDP doesn't.

[T] 4) Compared with UDP, TCP provides more functionalities but incurs higher overhead.

[F] 5) The transport layer protocols use the IP address to identify to which application a message should be sent.

[F] 6) In networking, "best effort" service means the same thing as "reliable" service (as provided by TCP, for example), in contrast to "reasonable effort" service where there are no guarantees that the data will ever reach the destination.

[F] 7) TCP connection establishment uses a three-way handshake so the TCP sender, the TCP receiver, and the sender's Internet Service Provider can all agree on a common set of options to be used for this session.

[F] 8) A two-dimensional parity code is designed for error detection, whereas a CRC code is designed for error correction

[T] 9) No two computers can have the same public IP address at the same time.

[F] 10) In the congestion avoidance phase, the size of the congestion window increases exponentially.

3. Short Answer Questions (50 points, 10 points each for 1, 2, and 3, 20 points for 4)

1) List 5 differences between the HTTP, SMTP, and DNS protocols.

1) HTTP and SMTP are TCP based but DNS is UDP based (Connection-based and connectionless)
2) HTTP and DNS are stateless but SMTP is stateful;
3) HTTP and SMTP have different request and response formats, DNS has the same format for requests and responses.
4) HTTP for web requests, SMTP for email, DNS for IP lookup.
5) HTTP and DNS is client pull and SMTP is client push.
6) HTTP and SMTP are ASCII-based, DNS is binary.

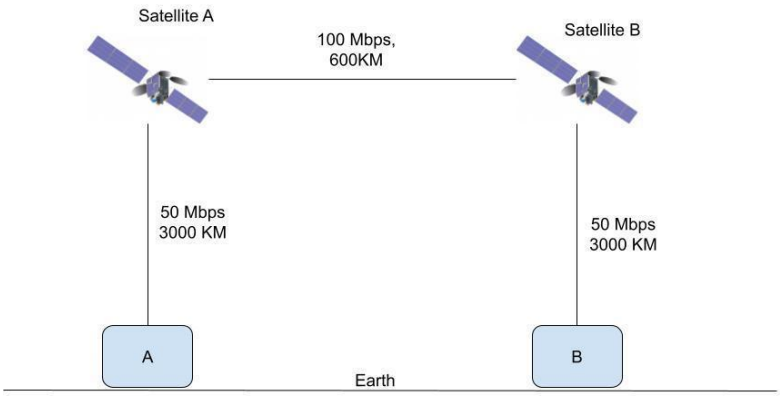
2) Why does TCP connect establishment require 3-way handshake, but connection termination needs 4-times waving?

Both connection establishment and termination require four steps: 1) client sends request; 2) server sends back ACK; 3) server sends request; 4) client sends back ACK. For TCP connection establishment, step 2 and 3 can be combined. For connection termination, they cannot be combined as the server may still send data to the client after receiving the client's request for closing the connection.

3) Consider sending a large file from a host to another over a TCP connection that has no loss.
a) Assume for each received TCP segment, an ACK is sent by the receiving side. Assume approximately constant round-trip times (RTT). Assume slow start threshold is 16. How long in terms of RTT does it take for cwnd to increase from 1MSS to 20 MSS (assuming no loss events)? While answer this question, please list the cwnd values at each RTT
b) What is the average throughout (in terms of MSS and RTT) for the aforementioned procedure (cwnd increases from 1MSS to 20 MSS)

a) 1MSS -> 2MSS -> 4MSS -> 8MSS -> 16MSS -> 17MSS -> 18MSS -> 19MSS ->20MSS
It takes 9 RTTs to increase from 1MSS to 20MSS
b) 1+2+4+8+16+17+18+19+20 / 9 = 105MSS / 9RTT = 11.67 MSS/RTT

4) Consider two hosts, A and B, connected by a star-link satellite network. The network adopts the store-and-forward switching strategy, and its topology is given by the graph below, where A communicates with Satellite A (SA for short), B communicates with Satellite B (SB for short), and Satellites A and B can communicate with each other.



Given that:

- the distance between A and SA is 3000KM, the distance between B and SB is 3000KM, the distance between SA and SB is 600KM;
- all signals in this system propagate at the speed of light, which is 3*10^8 m/s.
- the bandwidths of links (A, SA), (B, SB), and (SA, SB) are 50Mbps, 50Mbps, and 100 Mbps, respectively.

a) What is the one-way latency (first bit sent to last bit received) for sending a 1000-bit packet from A to B (if we only consider transmission delay and propagation delay)? [7 points]

Transmission delay = 2 * (1000/50*10^6) + (1000/100*10^6) = 0.00005 seconds
Propagation delay = 2 * (3,000,000 / 3 *10^8) + (600,000 / 3*10^8)= 0.022 seconds
Total delay = 0.02205 seconds.

b) Suppose that after A sends each 1000-bit packet to B, it waits for a 100-bit acknowledgment to be sent from B to A before sending the next packet. Assume there is no packet loss or bit errors. What is the long-term average throughput for sending data from A to B? (Throughput: an actual measure of how much data can be transferred from source to destination within a unit timeframe) [8 points]

ACK delay = 2 * (100/50*10^6) + (100/100*10^6) + 2 * (3,000,000 / 3 *10^8) + (600,000 / 3*10^8) = 0.022005s

Data transmitted from A to B = 1000bits
Throughput = 1000 bits / (0.02205s + 0.022005s) =22,698.899 bits/second or 0.022698899 Mbps

c) What is the bandwidth of the system. If we use the protocol defined in question 4.b), what is the utilization rate of the system bandwidth? [5 points]

The average bandwidth of the system is 50Mbps. The utilization rate is 0.023/50 = 0.00046 or 0.046%

d) (additional credit 10 points) To improve throughput, the system adopts a sliding window algorithm: A can send three 1000-bit packets to B before receiving any acknowledgments from B. For simplicity, we assume that B will only send back one 100-bit ACK packet for all three packets it receives in one transmission round. Assume there is no packet loss or bit errors. What is the long-term average throughput now? (think about: when will A start sending the 2nd 1000-bit packet?)

(2 * 0.00002s + 0.02205) + (0.022005 s) = 0.044095 seconds to send 3000 bits
3000 / 0.044095 = 0.068 Mbps
link utilization is 0.68/50 = 0.136%

If you have earned extra credits, please specify: