CS 352 Fall 2023
Midterm 2 (80 Minutes)

Please write with a dark pen or pencil

On my honor, I have neither received nor given any unauthorized assistance on this examination (assignment):

First Name: Akshaj

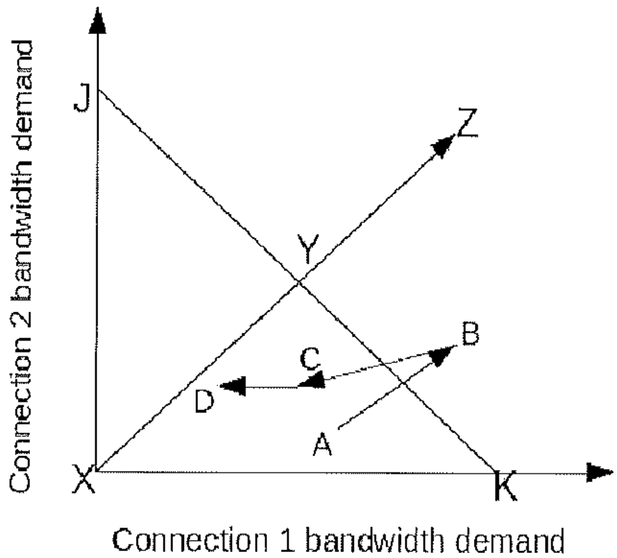
Last Name: Kammari

NetID: ak1990

Question	Score
Problem 1 (12 points)	
Problem 2 (6 points)	
Problem 3 (6 points)	
Problem 4 (9 points)	
Problem 5 (14 points)	
Problem 6 (12 points)	
Problem 7 (14 points)	
Problem 8 (9 points)	
Problem 9 (12 points)	
Problem 10 (6 points)	
Total (100 points)	

NetID: ____________

1. Additive Increase/Multiplicative Decrease (12 points)



The above diagram shows the bandwidth demand of two TCP connections. Connection 1's demand is on the X-axis and connection 2's demand is the Y-axis. Their demands can change with time. Write the line segment that corresponds to the the following events or statements:

a. **(3 points)** The maximum bandwidth of the bottleneck link available to both connection 1 and 2.

XY

b. **(3 points)** Both connection 1 and 2 increase the number of outstanding (i.e. unacknowledged) packets they will allow in the connection.

YZ

c. **(3 points)** The bandwidth demand of the bottleneck link was exceeded, both connection 1 and connection 2 observe a packet loss with duplicate acknowledgements, so both decrease their bandwidth demand.

BC

d. **(3 points)** Connection 1 decreases its demand, but connection 2 does not.

CD

NetID: zk1990

2. Little's Law (6 points)

a. **(3 Points)** In a network, you have an average of 200 data packets queued for transmission, and the network's transmission rate is 400 packets per second. What is the average delay (W) of the packets using Little's Law? You can leave your answer in unreduced form.

(mean arrival rate) * (mean response time)

$400w = 200$

$w = \frac{200}{400} = \frac{1}{2}$

$\boxed{0.5 \text{ seconds}}$

b. **(3 Points)** What would the average waiting time be if all the packets from the above problem exited the queue, but now we observe an average packet interarrival time of 0.0005 seconds per packet.

3 seconds

3. M//M/1 Queue (6 Points)

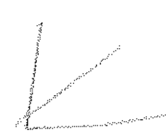
Recall in an M/M/1 queue, the probability of K items is $p_k = p^k \cdot p_0$

a. **(3 points)** what is meaning of p_0 in this equation?

initial utilization server

b. **(3 points)** Why must we keep multiplying p when we increase the value of k? You may use a diagram in your explanation.

linear growth



4. M/M/1 queue (9 Points)

A server can only process one packet at a time, and the processing time follows an exponential distribution with an average of 0.001 seconds per packet. Packets arrive according to a Poisson distribution, with an average rate of 700 packets per second. Analyze this M/M/1 queuing system. You may leave your answers in unreduced form:

a. **(3 points)** The average number of packets in the entire system.

$L = \lambda (1-\rho)$

$= (1-0.001)(700)$

b. **(3 points)** The average waiting time for a packet in the queue (not including the server)

$W = W_q + \frac{1}{\mu} \longrightarrow W_q = W - \frac{1}{\mu}$

avg. wait time for whole system

avg. wait time in queue

service rate of server

c. **(3 points)** The number of buffers needed to keep the packet loss rate below one in a hundred million.

$\lambda = 700$ pps

$\mu = 1/0.001 = 1000$ pps

5. Fair Queueing (14 Points)

a. **(5 points)** Consider a system with **Weighted Fair Queueing (WFQ)** scheduling. This system has four queues, each assigned a specific weight **(A: 3, B: 2, C:4, D:1)**. These queues are designed to be processed at a rate of 10 Mbps. Given the list of input traffic rates, complete the list of output rates for each of the queues.

Input rates (Mbps)				Output rates (Mbps)			
A	B	C	D	A	B	C	D
3	2	4	1	9	4	16	1

NetID: 9619 90

3 2 4 1

15	10	10	10	70	30	50	20
6	6	1	2	18	12	4	2
10	0	0	10	40	10	10	20
5	1	3	5	15	2	12	5

b. **(9 points)** Suppose a router has three input flows and one output. It receives the packets listed in the following table all at the same time in the router's WFQ computation, in the order listed (i.e., a very slight difference in real time). Assume the current virtual time is zero, and ties are broken by having packets which arrive first get priority. Assume the link rate is 1 Bps. For the Weighted Fair Queueing schedule fill in the table, and specify the order in which packets are transmitted.

Packet	Packet size (Byte)	Flow	Weight	Weighted Finish #
1	100	1	1	1
2	100	1	1	2
3	100	1	1	3
4	100	1	1	4
5	190	2	4	5
6	200	2	4	6
7	110	3	1	8
8	50	3	1	7

The transmission order is: ______________________

Finishing time of packet k of flow i is:

$$F_i^k = \max(F_i^{k-1}, V(t)) + \frac{L_i^k}{W_i}$$

L_i^k → length of packet k in flow i

W_i → weight of flow i

$V(t)$ → virt. time = 0

NetID: _______

6. Leaky Bucket (12 Points)

Suppose there is a leaky bucket at the host network interface. Network data rate is 2 MBps and the data rate on the link from the host to the bucket is 2.5 MBps.

a. **(6 points)** Assume the host wants to send 250 MB over the network in bursts. Calculate the minimum capacity of the bucket considering no data loss. You can leave your answer in unreduced form.

2.5 − 2 = 0.5 mb

$\frac{250}{2.5}$ = 100 bursts per second

(100)(0.5) = $\boxed{50 \text{ mb}}$

b. **(6 points)** Assume the capacity of the bucket is 100 MB. What is the longest burst time in order for no data to be lost?

$\boxed{50 \text{ seconds}}$

7. Token Bucket (14 Points)

a. **(4 points)** Assume a host needs to transmit 30 Mb of data over the network. There is a token bucket with the maximum capacity of 15 Mb, and a filling rate of 5 Mbps. The token bucket is initially full. Data transmission can occur only when there are available tokens in the bucket, otherwise they are queued until there are tokens available The host sends the data at a peak rate of 20 Mbps. How long does it take to send the entire 30 Mb of data through the network?

30 mb (15) 0 mb → 15 (5) 15 mb → 10 (5) 20 mb → 5 (5) 25 mb

0.5 1.5 2.5 3.5

$\boxed{4 \text{ seconds}}$

b. **(10 points)** Assume that we have a token bucket that has a fill rate of 10 KBps, a bucket size of 50 KB, and the bucket starts off full. There is a host that sends 15KB-packets every 0.5 seconds in a periodic manner, starting at t=0.5 seconds.

15 (50) 15 (35) 15 15 (30) 30 15 (15) 45 15 (10) 60

0.5 s 1 1.5 s 2.5 2.5 s

NetID: 9k1990

Data transmission can occur only when there are available tokens in the bucket, otherwise they are queued until there are tokens available and the queue can be of unlimited size. You can leave all your answers in unreduced form.

1. **(3 points)** How many tokens are left in the bucket after 1.5 seconds?

$\boxed{30 \text{ tokens}}$

2. **(3 points)** How long will it take until packets start to be queued?

$\boxed{2 \text{ seconds}}$

3. **(4 points)** Now, suppose the host can send data as much as it wants, whenever it wants. If the token bucket has a fill rate of 20 KBps, what would be the maximum possible burst size?

25 KB

8. Subnets (9 points)

You have been assigned the IP address range 192.168.0.0/24, and you need to create several subnets to accommodate different departments in your organization. You have the following requirements:

- Subnet A should support up to 30 hosts.
- Subnet B should support up to 20 hosts.
- Subnet C should support up to 10 hosts.

Calculate the subnet mask, network address, usable host addresses range, and the broadcast address for each subnets (A, B, and C).

192.168.0.0

NetID: [illegible]

(3 points) Subnet A:

192.168.0.0

(3 points) Subnet B:

192.168.0.0

(3 points) Subnet C:

192.168.0.0

9. CIDR (12 points)

An ISP has the address 128.64.3.0/24. Customer A wants 64 IP addresses, Customer B wants 32 IP addresses, Customer C wants 32 IP addresses, and Customer D wants 128 IP addresses. For each of the customers provide the appropriate CIDR mask and the range of IP addresses that each customer can use.

128 64.3.0

(3 points) Customer A:

128.64.3.0 - 128.64.64.0

(3 points) Customer B:

128.64.3.0 - 128.64.32.0

(3 points) Customer C:

128.64.3.0 - 128.64.32.0

(3 points) Customer D:

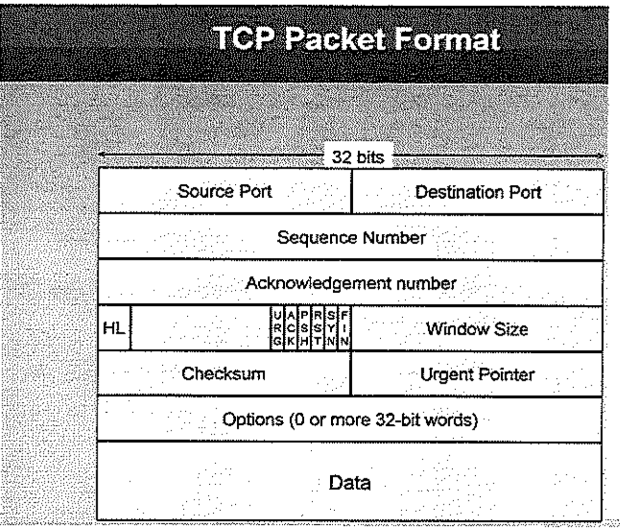
128.64.3.0 - 128.64.128.0

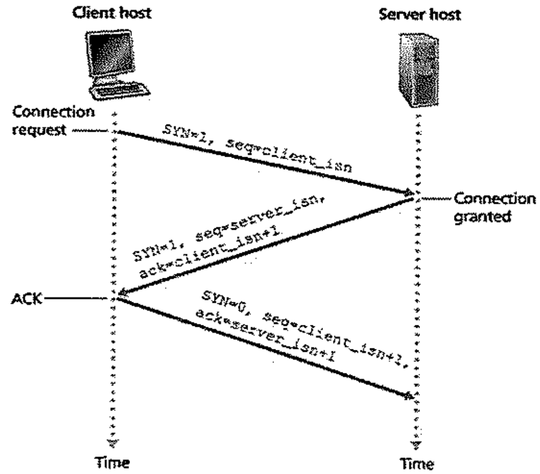
10. DHCP (6 points)

(6 points) What is the purpose of the DHCP protocol? (1-2 sentences)

More effective way of receiving IP addresses from server.

In order to measure the current load on the network, TCP uses only the last packet's ACK to measure the RTT used to set the timeout.(No it use several past cases)If TCP used the arithmetic mean of all packets ACKs' to compute the round-trip time (RTT) it would mean(past and recent observations influence TCP time out values at same level)What is put in the TCP header in order to accomplish flow control?(Correct answer:





The number of bytes the target host can accept)Why does TCP perform a retransmit immediately after three duplicate ACKs?(packet lost)
(Estimated RTT = (1-alpha) * old Estimated RTT + alpha * current RTT measurement)(Error = current RTT measurement - Estimated RTT)(Deviation = (1-beta) * old Deciation + beta * |Error|)(Time out = Estimated RTT + 4 * Deviation)(AIMD example start 2, threshold 8, time out at 5 and need tenth transmission: 2, 4, 8, 9, timeout and threshold become 4, 2, 4, 5, 6, 7(note linear mode increase is increasing 1 segments each time))(in the two dimensional TCP graph, the maximizes point is in the center of the graph) (Suppose a network router replaces a data packet with a bad checksum with a special error-reporting (ICMP) packet which is routed to the transmitter, but generating the error packet takes 10 times as long as simply forwarding the bad packet. Would Little's law apply to such a router, and why?
Yes, because the number of packets has remained unchanged from the case when there was no error.) (Suppose a web server drops requests it classifies as having originated from robot web-crawlers. We can show Little's law does not apply to such a server, referring to the proof used in class, because: We could not subtract the arrival and departure curves because the number of requests entering the system would differ from the number exiting.)(Over the course of an hour we observe a web server has 6000 requests arrive. We also observe that the average service time of a request is 0.5 seconds. Using Little' law, the average number of web requests in the server is: (6000/3600)*0.5 = 0.83)(little's law: L = lambda*W)

(A host is regulated by a token bucket. The token bucket is continuously filled at a rate of 0.2M tokens/sec. It is initially filled to capacity with 0.5M tokens. It takes 1 token for a data packet to be released into the network. Now suppose that data comes in three 1M-packet bursts (i.e., each burst contains 1M packets). Bursts occur at the beginning of the first, second, and third second, and each lasts for 500 msecs. Assume all packets are of the same size, and packets can depart at the same rate they arrive if tokens are available. (Just before the second burst arrives, there would be ____ packets left in the buffer. 1-0.5-0.2=0.3)Just before time 3 seconds, there would be ____ packets left in the buffer. 2-0.5-0.2-0.2=1.1(The computer would release all the packets into the network after ____ seconds. ???))

What are the two most important network-layer functions in a datagram network? What third function is additionally important in a virtual circuit network? Forwarding, Routing, Connection Setup

Given the routing table below, which link the packet will be routed on for a destination '192.168.0.78' IP address? calculate the subnet mask of the answer, Then look for the answer where the 192.168.0.78 fall into. 看 range

PurpleTurtles.com has been given a class C address, 73.223.89.0/24, and wants to form 3 subnets to support three departments: Dept. A: 55 hosts Dept. B: 24 hosts Dept. C: 100 hosts Which of the subnet network arrangement is correct(any within the correct range):

It is possible for IP fragments that makes up a given packet to take different routes to the target host. True or False? True

Which set of the below are valid reasons IP classes were abandoned for CIDR routing? A. CIDR reduced the size of the routing tables. B. Few organizations needed class As, leaving much of the address space unused. C. The class D address space was often too small, and a class C address was too small.

When traceroute, *** is ICMP disabled on that node

What CIDR mask is a class A address equivalent to? /8. /16 for class B and /32 for class C

Fair Queue

The special broadcast IP address of: 255.255.255.255 will send an IP datagram to all hosts on the sub-net.

The time-to-live (TTL) field in an IP packet:Is a counter which decremented for each routing hop and the packet is dropped if it reaches zero.

同时间小的走。

The DHCP protocol sends at least this many messages in order for a client to get an IP address from a server: 4

In the initial DHCP discover message, the destination IP address is: 255.255.255.255. and the source ip address is 0.0.0.0.

The traceroute program uses the ICMP protocol to discover intermediate network routers by sending UDP packets with the TTL field initially set to 1.

Suppose hosts A and B have the same netmask M. Host A has IP address 102.45.56.7. Host B has IP address 102.46.47.8. The netmask M is 255.252.0.0. Are A and B in the same IP network? Why or why not?

Answer: xxxx/4 => sub net mask = 1111 0000......

For xxxx/30 IP for others other than your machine and range

M = 11111111 11111100 00000000 00000000

32-30 -> 2 bits => 2^2=4

A = 01100110 00101101 00111000 00000111

4-2=2 2 ips

B = 01100110 00101110 00101111 00001000

We see that A & M == 102.44.0.0; and that B & M == 102.44.0.0.

Since A & M == B & M, they are in the same IP network.Given the CIDR notation 172.16.0.0/20, calculate the subnet mask, and the range of usable IP addresses.

Answer:

Subnet mask => 255.255.240.0

Range of usable IP addresses => 12 bit available for host. 2^12 host addresses 172.16.0.1 to 172.16.15.254

1 milliseconds = 0.001 seconds

Seconds	Packet arrival (Mb)	Token count at the beginning of the second (Mb)	Token count at the end of the second (Mb)	Token generated rate (Mb/sec)	Packets left at the beginning of the second	Packets left at the end of the second	Comment
1	1	0.5	0	0.2	-	1. - 0.5 - 0.2 = 0.3	Generated 0.2Mb token, forwarded 0.5Mb
2	1	0	0	0.2	0.3	1. + 0.3 - 0.2 = 1.1	Generated 0.2Mb token, forwarded 0.2Mb
3	1	0	0	0.2	2.1	2.1 - 0.2 = 1.9	Forwarded 0.2Mb
4	0	0	0	0.2	1.9	1.9 - 0.2 = 1.7	Forwarded 0.2Mb
5	0	0	0	0.2	1.7	1.7 - 0.2 = 1.5	Forwarded 0.2Mb
6	0	0	0	0.2	1.5	1.5 - 0.2 = 1.3	Forwarded 0.2Mb
7	0	0	0	0.2	1.3	1.3 - 0.2 = 1.1	Forwarded 0.2Mb
8	0	0	0	0.2	1.1	1.1 - 0.2 = 0.9	Forwarded 0.2Mb
9	0	0	0	0.2	0.9	0.9 - 0.2 = 0.7	Forwarded 0.2Mb
10	0	0	0	0.2	0.7	0.7 - 0.2 = 0.5	Forwarded 0.2Mb
11	0	0	0	0.2	0.5	0.5 - 0.2 = 0.3	Forwarded 0.2Mb
12	0	0	0	0.2	0.3	0.3 - 0.2 = 0.1	Forwarded 0.2Mb
13	0	0	0	0.2	0.1	0.1-0.1 = 0.	Forwarded 0.1Mb

1. Traffic to a message switching center for one of the outgoing communication lines arrives in a random pattern at an average rate of 240 messages per minute. The line has a transmission rate of 800 characters per second. The message length distribution (including control characters) is approximately exponential with an average length of 176 characters. Calculate the following principal statistical measures of system performance, assuming that a very large number of message buffers are provided:
   a. Average number of messages in the system?
   b. Average number of messages in the queue waiting to be transmitted?
   c. Probability that 10 or more messages are waiting to be transmitted (not including the message being transmitted)?

Answer:

Parameters: Average message length/line speed = 176/800 = 0.22 μ = 1/0.22 = 4.55 message/sec λ = 4 message\sec ρ = 0.88

$\rho = \frac{\lambda}{\mu}$

A. L = ρ / (1- ρ) = 7.33 B. . Lq = "ρ" ^2 / (1- ρ) = 6.45 C. P {11 or more messages in the system} = P{N ≥ 11} = "ρ" ^11 = 0.245

更正，这里是 ρ^{10}

2. Computer A has 19.5 MB to send on a network and transmits the data in a burst of 6 Mbps. The maximum transmission rate across routers is 4 Mbps. If computer A's transmission is shaped using a leaky bucket, how much capacity must the queue in the bucket hold so as not to discard any data?

Answer:

Time to transmit the data in a burst => (19.5 * 8) / 6 = 26 sec.

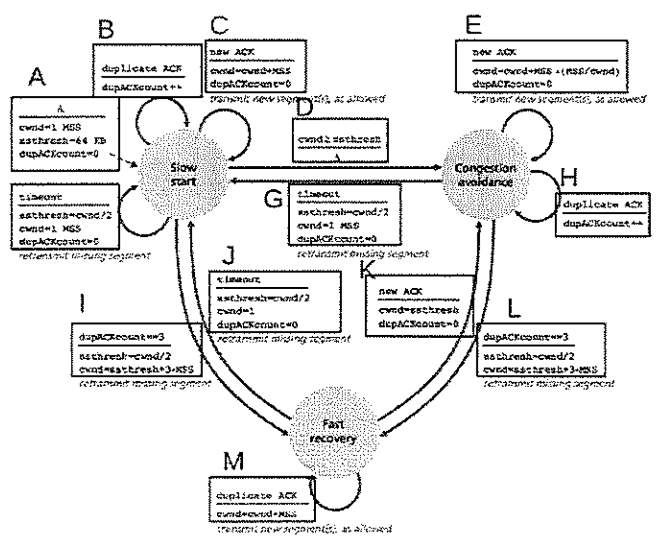
Actual data transmitted in 26 sec => 4 * 26 = 13 Mbytes

Bucket size => 19.5 MB – 13 MB = 6.5 MB

3. Over the course of an hour we observe a web server has 6000 requests arrive. We also observe that the average service time of a request is 0.5 seconds. Using Little' law, the average number of web requests in the server is:

Answer:

L = λ * W = (6000/3600) * 0.5 = 0.8333



C. When an acknowledgement arrives, TCP increases the congestion window in order to double the window size for each (approximate) round-trip time. **E.** When an acknowledgment arrives, TCP increases the congestion window in order to increase the window size by 1 segment for each (approximate) round- trip time. **J.** When a timeout occurs, TCP resets the theshold to half the congestion window, then resets the congestion window to 1, then enters slow start, while it was waiting for an acknowledgement that would have allowed TCP to return to congestion avoidance mode after having seen 3 duplicate acks. **K.** When an acknowledgement arrives, the congestion window is set to the threshold in order to reduce the window size, but not by as much as a slow start.

λ = arrival rate of jobs

μ = Service rate of the server

L = average number of events in the system

L_q = average number of events in queue

W = average waiting time in the whole system

W_q = average waiting time in queue

$L = \lambda W = \left(\frac{N}{T}\right) W$ $W = W_q + \frac{1}{\mu}$

$L_q = \lambda W_q$

$\rho = \frac{\lambda}{\mu}$ $L = \frac{\lambda}{\mu - \lambda}$; $W = \frac{1}{\mu - \lambda}$

$W_q = \frac{\lambda}{\mu(\mu-\lambda)}$ $L_q = \frac{\lambda^2}{\mu(\mu-\lambda)}$

$\lambda < \mu$ ✓

$\lambda > \mu$ the queue is unstable