Student Name: _____
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King Fahd University of Petroleum and Minerals
College of Computer Sciences and Engineering
Department of Computer Engineering

COE 344 – Computer Networks (T072)

Final Exam

Date & Time: Saturday June 07, 2008 (07:00 PM – 09:00 PM)

Problem #	Mark	Score
1	40	
2	20	
3	20	
4	20	
Total	100	

- **This is a CLOSED books, CLOSED notes exam.**
- **State all your assumptions. Show all your work. NO credit will be given if work is not shown.**
- **Answer ALL problems.**

Problem # 1 (40 marks)

A. *(1 point each)* Choose only one answer that is the most appropriate.

1) The purpose of the transport layer always include(s):
   a) guarantee reliable data transfer
   b) ensure in-order delivery
   c) provide for a delivery service between two processes running on the end systems
   d) both [A] and [B]
   e) both [A] and [C]
   f) both [B] and [C]
   g) all of [A], [B], and [C]
   h) none of the above

2) When a TCP segment arrives to a host, the socket to which the segment is directed to depends on:
   a) the destination port number
   b) the source port number
   c) the source IP address of the datagram that encapsulated the segment
   d) all of the above
   e) none of the above

3) Timeout value for receiving the acknowledgement of a segment sent over a TCP connection is determined:
   a) By the Application layer mechanism implemented in a user-defined algorithm
   b) Is based on the size of the segment
   c) Based on TCP slow-start algorithm
   d) Based on multiples of round-trip time estimates

4) UDP has which of the following characteristics?
   a) three-way hand shake for connection establishment
   b) connection state at the server
   c) no error checking
   d) all of the above
   e) none of the above

5) At TCP's timeout loss event:
   a) Threshold is reduced to 1 MSS
   b) CongWin is reduced to 1 MSS
   c) Threshold is reduced to 1/2 of CongWin
   d) CongWin is doubled
   e) Both [A] and [B]
   f) Both [A] and [D]
   g) Both [B] and [C]
   h) [A], [C], and [D]
   i) None of [A]—[D]

6) In routing among ASs, which of the following issues dominate(s)?
   a) current congestion levels in the ASs
   b) number of ASs traversed
   c) policy
   d) geographical distance between ASs
   e) all of the above
   f) none of the above

7) Isolated ***collision*** domains can be achieved by using _____.
   a) hubs
   b) switches
   c) routers
   d) both [A] and [B]
   e) both [A] and [C]
   f) both [B] and [C]
   g) all of [A], [B], and [C]
   h) none of the above

8) Isolated ***broadcast*** domains can be achieved by using _____.
   a) hubs
   b) switches
   c) routers
   d) both [A] and [B]
   e) both [A] and [C]
   f) both [B] and [C]
   g) all of [A], [B], and [C]
   h) none of the above

9) When a router receives and accepts a link layer frame that is destined to some end system, the next step the router will do is _____.
   a) broadcast the frame over all outgoing interfaces
   b) send the frame over an outgoing interface whose MAC address matches the MAC address included in the received frame
   c) send an ARP query on all outgoing interfaces to obtain the MAC address to be used next for routing
   d) consult its own ARP table to determine the MAC address to be used next for routing
   e) send the included datagram to its own network layer so that the network layer performs a forwarding table lookup to determine the proper outgoing interface to be used
   f) none of the above

10) In the figure shown, datagrams sent by router *A* and delivered to router *B* _____ .

   a) are guaranteed to be received by router *B* in-order (i.e. same order as sent by router *A*)
   b) are guaranteed to be received by router *B* out-of-order
   c) could be received by router *B* out-of-order dependent on the ATM service model used
   d) are not possible as ATM and IP use different protocols

11) Ethernet provides which of the following services to the network layer
    a) reliable data transfer
    b) flow control
    c) error detection
    d) all of the above
    e) none of the above

12) If an Ethernet adapter determines that a received frame is addressed to a different adapter, it takes the following action(s):
    a) It sends a negative acknowledgement to the sending host
    b) It delivers the frame to the network layer
    c) It discards the frame
    d) It *does* send an ICMP error message
    e) Both [A] and [B]
    f) Both [B] and [C]
    g) Both [C] and [D]
    h) Both [A] and [C]
    i) Both [A] and [D]
    j) All of [A]—[D]
    k) None of [A]—[D]

13) Suppose that an Ethernet node, which uses CSMA/CD protocol, constructs a frame and then senses that the channel is busy. Then the adapter
    a) Waits until it senses the channel is idle for 96 bit times, then begins to transmit the frame
    b) Polls a master node for permission to transmit
    c) Does **not** enter exponential backoff
    d) Begins to transmit the frame but listens to the channel during transmission
    e) Both [A] and [B]
    f) Both [B] and [C]
    g) Both [C] and [D]
    h) Both [A] and [C]
    i) Both [A] and [D]
    j) All of [A]—[D]
    k) None of [A]—[D]

14) Ethernets:
    a) Use CSMA/CD
    b) Use Manchester encoding for 10BaseT
    c) Some variants can run at a data rate of 1 Gbps
    d) Both [A] and [B]
    e) Both [A] and [C]
    f) Both [B] and [C]
    g) All of [A]—[C]
    h) None of [A]—[C]

15) A channel partitioning protocol has the following characteristic(s):
   a) All transmitting nodes get the same amount of bandwidth
   b) It is collision-free
   c) It may cause *silent periods*
   d) Both [A] and [B]
   e) Both [A] and [C]
   f) Both [B] and [C]
   g) All of [A]—[C]
   h) None of [A]—[C]

16) A cut-through switch has which of the following properties:
   a) a packet may be leaving and entering the switch at the same time
   b) a packet is forwarded through the switch without a store-and-forwarding delay when the output link is free
   c) does not provide a performance improvement over store and forward if the output links are always congested
   d) all of the above

17) Hubs, switches, and routers:
   a) Switches have the most optimized routes
   b) Hubs process frames faster than switches
   c) Hubs and switches are plug and play
   d) Routers are multi-point hubs
   e) Both [A] and [B]
   f) Both [A] and [C]
   g) Both [B] and [C]
   h) Both [C] and [D]
   i) [A], [B], and [C]
   j) All of [A]—[D]

18) RIP is
   a) an intra-AS protocol
   b) an inter-AS protocol
   c) based on Distance Vector Routing
   d) allows multiple same cost paths
   e) Both [A] and [C]
   f) Both [B] and [C]
   g) [A], [C] and [D]
   h) [B], [C] and [D]
   i) All of [A]—[D]
   j) None of [A]—[D]

19) OSPF is
   a) an intra-AS protocol
   b) has security features
   c) can route packets differently based on type of service
   d) based on distance vector routing
   e) Both [A] and [B]
   f) Both [A] and [C]
   g) [A], [B] and [C]
   h) [B], [C], and [D]
   i) All of [A]—[D]
   j) None of [A]—[D]

20) BGP is
   a) a path vector protocol
   b) concerned with Policy based routing
   c) based on link state protocol
   d) does not use route advertisements
   e) Both [A] and [B]
   f) Both [B] and [C]
   g) [A], [B], and [C]
   h) [A], [B], and [D]
   i) All of [A]—[D]
   j) None of [A]—[D]

21) **Connection-Oriented (CO)** service**:**
   a) Requires setup & disconnect phase
   b) Can provide reliable service
   c) Requires state information in switches
   d) Higher startup time than connectionless
   e) Both [A] and [B]
   f) Both [B] and [C]
   g) Both [C] and [D]
   h) Both [A] and [C]
   i) All of [A]—[D]
   j) None of [A]—[D]

22) **Connection-Less (CL)** service:
   a) Has *no* setup or disconnect phase (every packet has address)
   b) Provides best effort service
   c) Does NOT require state information in switches
   d) Works better than CO if some nodes fail
   e) Both [A] and [B]
   f) Both [B] and [C]
   g) Both [C] and [D]
   h) Both [A] and [C]
   i) All of [A]—[D]
   j) None of [A]—[D]

23) Which of the following methods can be used to set up an IP address on a workstation?
   a) An IP address is configured for the workstation by an administrator
   b) A dynamic address is configured on the workstation by the ARP protocol
   c) A dynamic address is obtained from a DHCP server
   d) An IP address is obtained from the station's Ethernet adaptor
   e) Both [A] and [B]
   f) Both [A] and [C]
   g) Both [C] and [D]
   h) [A], [B], and [C]
   i) [B], [C], and [D]
   j) All of [A]—[D]

24) Ad hoc wireless networks
   a) Don't use centralized base stations
   b) May exhibit hidden terminal problems
   c) Need an access point (AP) to operate
   d) Efficiently run CSMA/CD protocol
   e) Both [A] and [B]
   f) Both [B] and [C]
   g) Both [C] and [D]
   h) Both [A] and [C]
   i) Both [A] and [D]
   j) All of [A]—[D]
   k) None of [A]—[D]

25) The IEEE 802.11 protocols can use RTS-CTS frames to _____.
   a) Reserve access to the shared channel
   b) Enhance the signal strength
   c) Reduce the signal strength
   d) Detect collisions
   e) Both [A] and [D]
   f) All of the above
   g) None of the above

26) From the attached ISP router perspective, a NAT-enabled router looks like _____.
   a) an inter-AS router
   b) an intra-AS router
   c) a single device with a single IP address
   d) all of the above
   e) none of the above

27) IEEE 802.11 uses CSMA/CA because_____ .
   a) CSMA/CA resolves the hidden terminal problem
   b) CSMA/CA resolves the issue of fading
   c) unlike CSMA/CD, CSMA/CA does not use acknowledgements for received data
   d) both a. and b.
   e) both a. and c.
   f) both b. and c.
   g) all of a., b., and c.
   h) none of the above

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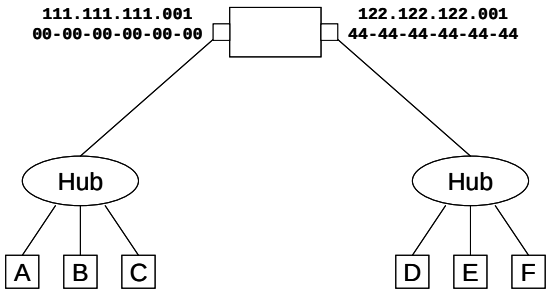
28) Consider sending a 3000-byte datagram (inclusive of a minimum size header) from a host to another host over IPv6–only network. Along the path between the two hosts, the datagram will go over a link whose MTU is 500 bytes (inclusive of a minimum size header). Thus, the number of ***fragments*** generated by the router immediately preceding the specified link is:
   a) 6
   b) 7
   c) no fragments will be generated
   d) cannot be determined from given information

29) When a switch transmits an Ethernet frame on a specific interface, the Ethernet frame has:
   a) the switch's LAN address as the frame's source address
   b) the switch's LAN address as the frame's destination address
   c) the broadcast address as the frame's source address
   d) None of the above

30) The device connecting the two hubs in the figure shown must be a:
   a) hub
   b) switch
   c) router
   d) Both [A] and [B]
   e) Both [A] and [C]
   f) Both [B] and [C]
   g) All of [A]—[C]
   h) None of [A]—[C]



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B. *(1 point each)* Mark the following with T (true) or F (false).

	Statement	T / F
1.	Suppose that host A wants to send data over TCP to host B, and host B wants to send data to host A over TCP. Two separate TCP connections, one for each direction, must be established.	
2.	Network congestion has ***no*** impact on the process of IP fragmentation.	
3.	If a mobile node wishes to transmit a datagram to a stationary correspondent, then, from an efficiency point of view, the direct routing approach is preferred over the indirect routing approach.	
4.	With CDMA, two concurrent (simultaneous) senders in the same network must use the same chipping code.	
5.	Consider a twisted-pair Ethernet in which all nodes are 50 meters from the hub. The time it takes for a bit to propagate from hub to node for a 10BaseT Ethernet is ten times longer than for a 100BaseT Ethernet.	
6.	CSMA/CD is more restrictive than the CSMA in the sense that it puts restrictions on the cable lengths and frame sizes.	
7.	Pure ALOHA results in higher peak channel utilization compared to the slotted ALOHA.	
8.	In CSMA/CD, after the 4^{th} collision, the probability that a colliding node chooses $K = 0$ in the exponential backoff algorithm is zero (i.e., $P\{K=0\} = 0$).	
9.	In wireless networking, TCP congestion control does ***not*** decrease the congestion window size when a loss event occurs due to a lost segment caused by RF conditions.	
10.	If every link in the internet was designed to provide reliable delivery service between nodes connected to the link, then the TCP reliable delivery service is completely redundant.	

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Problem # 2 (20 marks)

Assume that TCP *Reno* is used in a network, and that the following events are taking place:

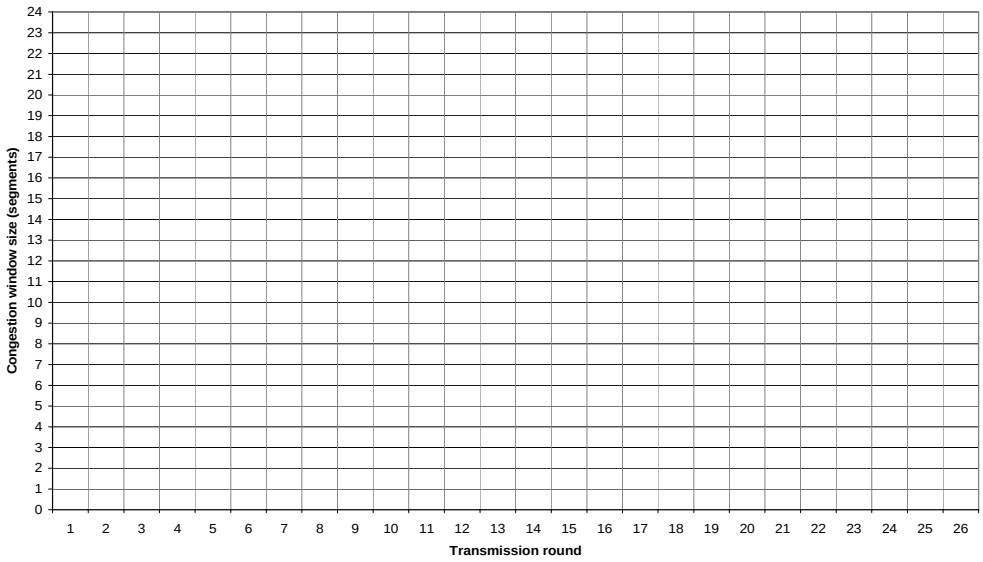
- At transmission round 1 a new round of transmissions begins.
- At transmission round 5 the Threshold is reached.
- *After* transmission round 7, a segment loss was detected by a triple duplicate ACK.
- *After* transmission round 15, a segment loss was detected by a timeout.
- *After* transmission round 23, a segment loss was detected by a timeout.
- *After* transmission round 26, the transmission is completed.

Answer the following based on the behavior discussed above:

1. ***(4 points)*** What is the initial value of Threshold at the first transmission round?

2. ***(1 point)*** After transmission round 7, is TCP slow start operating or TCP congestion avoidance operating?

3. ***(10 points)*** Use the following figure to plot the TCP congestion window size as a function of the transmission rounds up to and including round 26.



4. ***(3 points)*** Based on the plot obtained in part 3, during what transmission round is the 100^{th} segment sent?

5. ***(2 points)*** Suppose that the size of each transmitted segment is fixed and is equal to 200 bytes. Furthermore, suppose that the bytes transmitted are numbered starting from 0. What is the sequence number of the last segment transmitted in transmission round 3?

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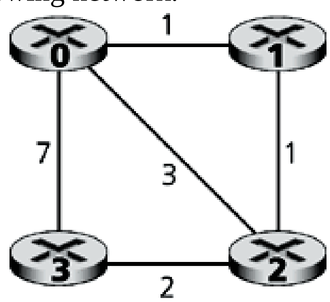
Problem # 3 (20 marks)

A. ***(10 points)*** Consider the following network.



Suppose that the link cost *c*(0,3) has changed from 7 to 1, re-compute the distance tables for nodes 0, 1, 2, and 3 after each iteration of a synchronous version of the distance vector algorithm using as many of the following tables as needed. Note that the tables' values *prior* to the link cost change are as shown in the leftmost column of the tables.

cost to (from)

D^0	0	1	2	3
0	0	1	2	4
1	1	0	1	3
2	2	1	0	2
3	4	3	2	0

cost to (from)

D^0	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^0	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^0	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^0	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^1	0	1	2	3
0	0	1	2	4
1	1	0	1	3
2	2	1	0	2
3	∞	∞	∞	∞

cost to (from)

D^1	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^1	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^1	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^1	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^2	0	1	2	3
0	0	1	2	4
1	1	0	1	3
2	2	1	0	2
3	4	3	2	0

cost to (from)

D^2	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^2	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^2	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^2	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^3	0	1	2	3
0	0	1	2	4
1	∞	∞	∞	∞
2	2	1	0	2
3	4	3	2	0

cost to (from)

D^3	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^3	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^3	0	1	2	3
0				
1				
2				
3				

cost to (from)

D^3	0	1	2	3
0				
1				
2				
3				

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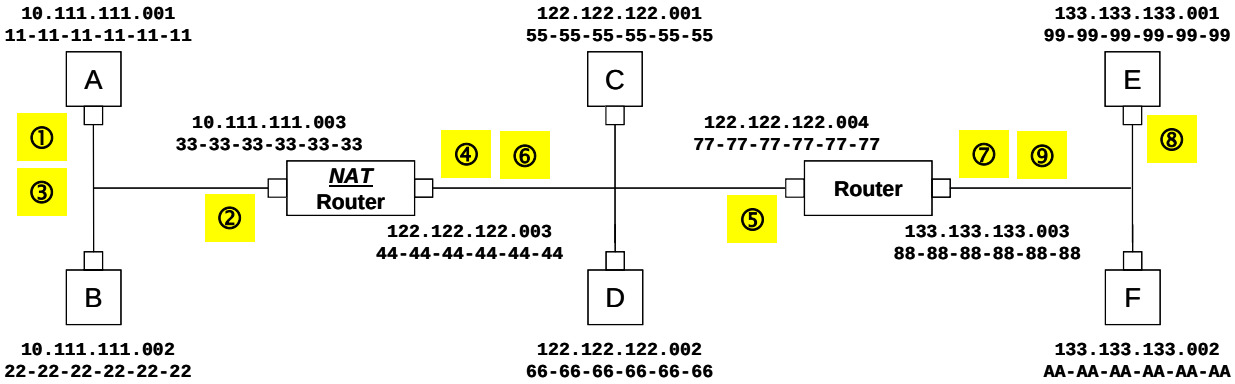
B. ***(10 points)*** Consider the following network. Hosts *A* and *B* belong to a private network hidden behind the **NAT** router, whereas hosts *C*, *D*, *E*, and *F* belong to the Internet network. Suppose that host *A* wants to send a TCP segment to host *E*. Assuming that all ARP tables are *empty*, complete the following table regarding the nine data link frames shown in the figure (i.e. frames ①,②,③,④,⑤, ⑥, ⑦, ⑧, and ⑨) pertaining to the TCP segment sent from *A* to *E*. Note that the possible frame types are ***ARP Query***, ***ARP Response***, and ***data***.



Frame	*Frame type*	*Source MAC*	*Destination MAC*	*Source IP*	*Destination IP*
①					
②					
③					
④					
⑤					
⑥					
⑦					
⑧					
⑨					

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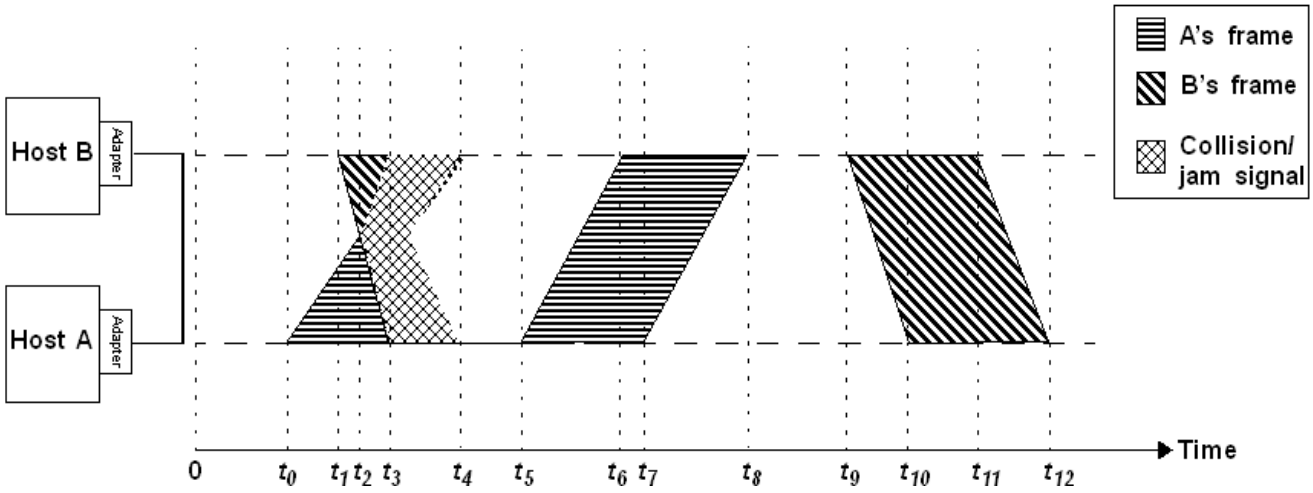
Problem # 4 (20 marks)

Consider two nodes A and B connected through an Ethernet segment. Following space-time diagram represents the frame transmission attempts by hosts A and B through the length of shared link over time.



A. ***(6 points)*** For the given space-time diagram, indicate the time/duration of following events/operations specified in the following table in terms of t_i or t_i - t_j, respectively.

Event/operation	Time and/or Duration
Time at which the first bit of host A's frame collides with the first bit of host B's frame	
Latency of channel becoming idle after A and B detect the first noise bits after collision	
Latency of retransmitting the first bit of frame by host A (duration from after A detects the channel to be idle following the collision signals until the end of backoff period)	
Latency of retransmitting the first bit of frame by host B (duration from after B detects the channel to be idle following the collision signals until the end of backoff period)	
Propagation delay from host A to host B	
Transmission delay of host B's frame	

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B. ***(14 points)*** For the same given space-time diagram, if the propagation delay from host *A* to *B* (as well as, *B* to *A*) is 200 bit times and both *A* and *B* exchange a minimum sized Ethernet frame (i.e. 72 bytes), find values of t_i's given in the following table in terms of bit times starting from 0. Assume value of *K* used in CSMA/CD algorithm by *A* (K_A) is **1** and one used by *B* (K_B) is **4** after collision. Use t_3 = 800 bit times from the beginning (0).

Event instant	**Time (bit times with respect to beginning from 0)**
t_4	
t_5	
t_6	
t_7	
t_8	
t_9	
t_{12}	