Department of Computer Science and Engineering

CSE 3214: Computer Network Protocols and Applications

Final Examination

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Date: April 15, 2010

Instructions:

- Examination time: 180 min.
- Print your name and CS student number in the space provided below.
- This examination is closed book and closed notes. Use of calculators is allowed.
- There are 8 questions. The points for each question are given in square brackets, next to the question title. The overall maximum score is 100.
- Answer each question in the space provided. If you need to continue an answer onto the back of a page, clearly indicate that and label the continuation with the question number.

FIRST NAME: ______________________________

LAST NAME: ______________________________

STUDENT #: ______________________________

Question	Points
1	/ 10
2	/ 8
3	/ 14
4	/ 15
5	/ 8
6	/ 10
7	/ 17
8	/ 18
Total	/ 100

1. Multiple Choice, True/False [10 points]

1.1) Multiple choice questions – each question is worth [1 point].

a) The loopback (IP) address is a member of:

(a) Class A network.
(b) Class B network.
(c) Class C network.
(d) None of the above.

b) IPv6 addresses are ___________________ bytes long.

(a) 8
(b) 16
(c) 32
(d) 128

c) What is usually returned when a request is made to connect to a TCP port at which no server is listening?

(a) A TCP segment with the ACK and SYN bits set to 1.
(b) A TCP segment with the ACK and FIN bits set to 1.
(c) A TCP segment with the ACK and RST bits set to 1.
(d) A TCP segment with the ACK and PSH bits set to 1.

d) Which of the following are true statements about TCP.

(a) The slow-start algorithm increases a source's rate of transmission faster than the additive-increase.

(b) Setting RTO (retransmission timeout value) to a value less than the measured RTT may lead to unnecessary retransmissions.

(c) TCP segments can only be lost when router queues overflow.

(d) TCP connection termination procedure is called two-way handshaking.

e) In a network, after the load reaches and exceeds the capacity, throughput __________________ .

(a) Increases sharply.
(b) Increases proportionally with the load.
(c) Declines sharply.
(d) Declines proportionally with the load.

f) The HTTP request line contains a ________________ method to get information about a document without retrieving the document itself.

(a) HEAD.

(b) POST.

(c) COPY.

(d) None of the above.

g) DNS can use the services of ___________________ on the well-know port 53.

(a) UDP.

(b) TCP.

(c) Either (a) or (b).

(d) None of the above.

h) Suppose a Certificate Authority (CA) has Bob's certificate registered with it, binding Bob's public key to Bob. This certificate is signed with:

(a) Bob's public key.

(b) The CA's public key.

(c) Bob's private key.

(d) The CA's private key.

i) Suppose we choose a small (rather than a bigger) fixed playout delay for a real-time interactive multimedia application. This will result i:

(a) Less loss, less interactivity.

(b) Less loss, higher interactivity.

(c) More loss, less interactivity.

(d) More loss, higher interactivity.

j) The _____________________ (shaping) algorithm allows idle hosts to accumulate credit for the future transmissions.

(a) Leaky bucket.

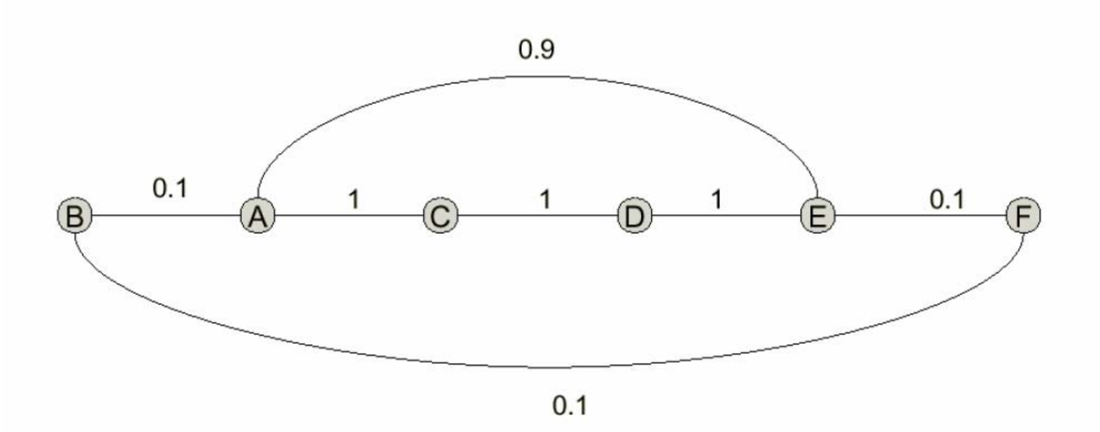
(b) Token bucket.

(c) Early random detection.

(d) None of the above.

2. Routing [8 points]

In this problem you will be asked to compute distance vector(s) using the Bellman Ford algorithm for the network below:

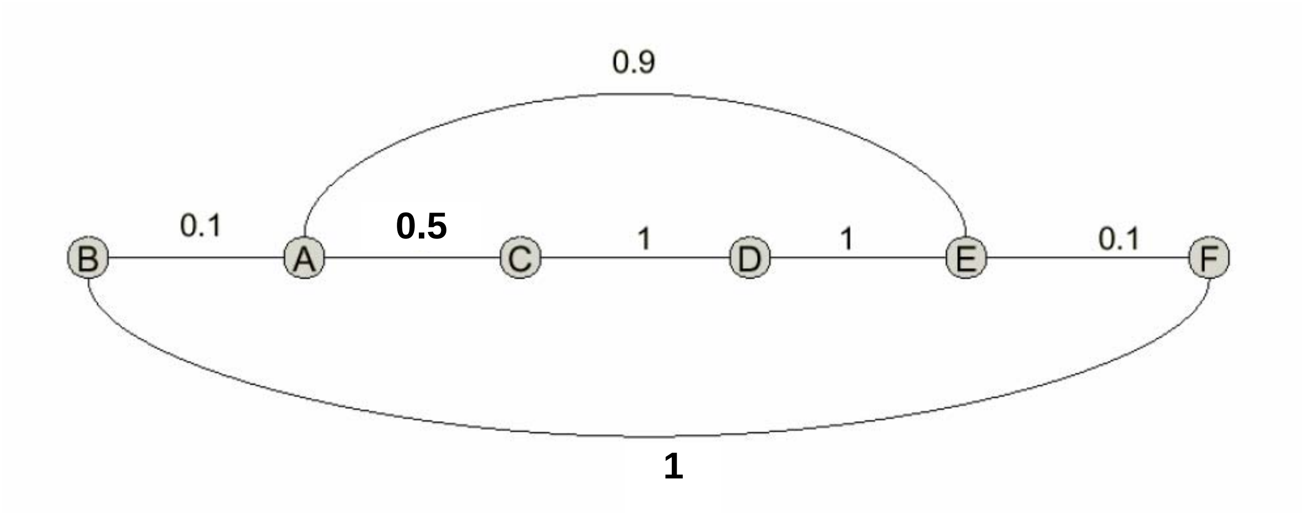


Assume that time is slotted (t=1, 2, 3, …) and that a node sends its distance vector estimates to its neighbors at the beginning of each slot. A distance vector estimate sent at the beginning of a slot arrives at the end of that slot. All distance estimates are computed using the most recently available estimates.

2.1) [5 points] For the above stated problem, what are node A's distance vectors at the beginning of the time slots 1, 2, 3, and 4?

	A	B	C	D	E	F
1						
2						
3						
4						

2.2) [3 points] This time assume that the cost/weight of link AC is 0.5, while the cost/weight of link BF is 1. How many iterations are required, in this case, for A's distance vectors to converge?



	A	B	C	D	E	F
1						
2						
3						
4						

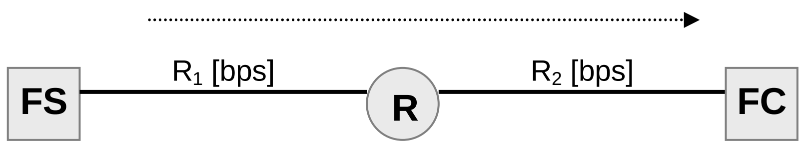
3. Packet Switching / Network Layer Potpourri [14 points]

3.1 [9 points] Assume there is one router and two links between the file server and client, as shown in the figure below. The first link has transmission rate R_1 and the second link has transmission rate R_2. Assume the file gets broken into three packets, each of size L. Ignore all propagation and processing delays. Answer the following thee questions:

(a) How long does it take from when the server starts sending the file until the client has received the whole file if $\mathbf{R_1 \leq R_2}$?

(b) How long does it take from when the server starts sending the file until the client has received the whole file if $\mathbf{R_1 > R_2}$?

(c) In case (b), how long does the second packet spend in the router's queue?



3.2 [5 points] A router has the following CIDR entries in its routing table:

Address/mask	**Next hop**
135.46.56.0/22	**Interface 0**
135.46.60.0/22	**Interface 1**
192.53.40.0/23	**Router 1**
default	**Router 2**

For each of the following IP addresses, what does the router do if a packet with that address arrives?

(a) 135.46.63.10

(b) 135.46.57.14

(c) 135.46.52.2

(d) 192.53.40.7

(e) 192.53.56.7

4. TCP Potpourri [15 points]

4.1) [5 points] Consider a TCP connection between two machines (A and B) in an environment with 0% packet loss. Assume the round trip time (RTT) between the two machines is 4 [seconds], and the segment size is 3 [Kbytes]. The bandwidth of the connection is 500 [kbps]. What is the smallest TCP window size for which there will be no stalling? (We say a TCP connection experiences no stalling if the acknowledgments arrive back to the sending machine before the sliding window over the send buffer close to zero. I.e., TCP packets are continuously, back-to-back, sent out of the sending machine.) Justify your answer!

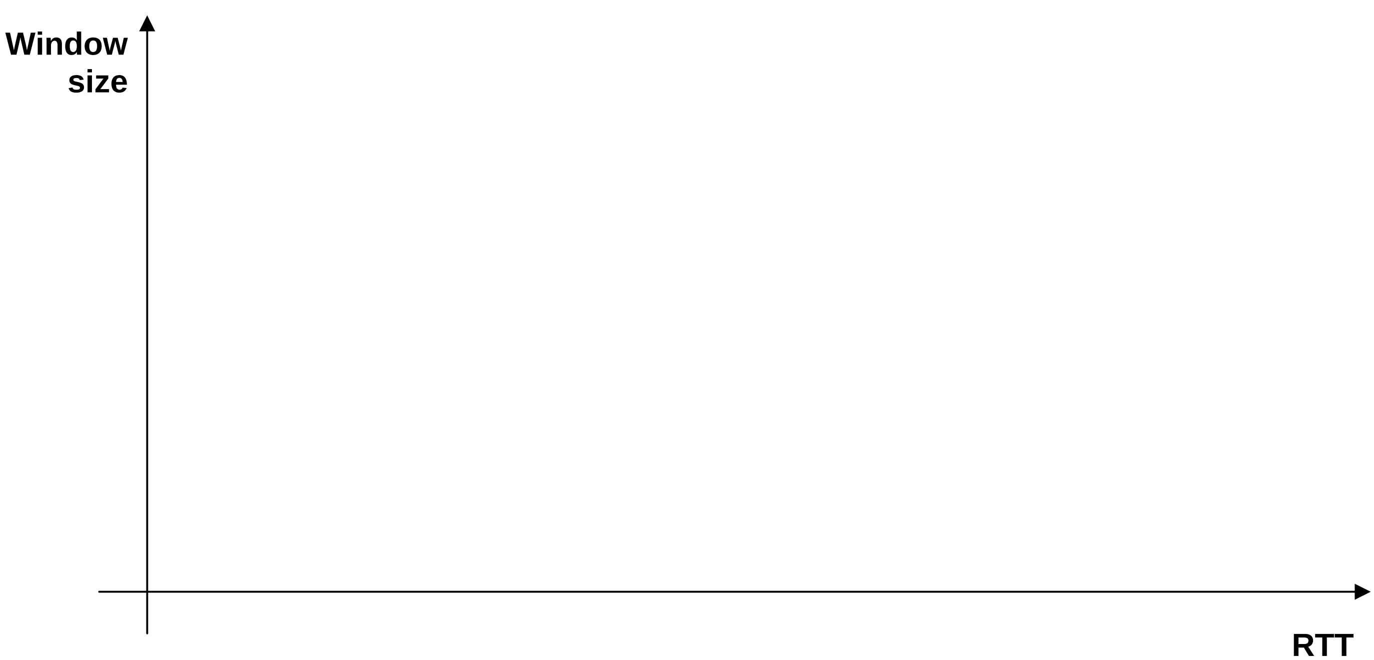
4.2) [5 points] Assume that a TCP process A first measures the actual round trip time to another TCP process to be 30 ms, and A thus sets its estimated round trip time to be 30 ms. The next actual round trip time that A measures is 60 ms. In response, A increases its estimated round trip to 50 ms. The next actual round trip time that A sees is 40 ms. What is the next estimated round trip computed by A? Justify your answer.

4.3) [5 points] Consider an additive-increase multiplicative-decrease congestion control algorithm (window size increases linearly and it is halved when congestion is detected), with no slow start, that also works in units of packets rather than bytes. The algorithm starts each connection with a congestion window equal to one packet. Assume that the delay is only due to propagation (infinite transmission capacity) and when a group of packets is sent, only a single cumulative acknowledgment is returned.

Fill out the table below, and consequently plot the size of congestion window as a function of the round-trip times for the situation in which the following packets are lost: 9, 25, 30, 49. For simplicity assume a perfect timeout mechanism that detects a lost packet exactly 1 RTT after it is transmitted.

RTT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Window size									
Packet sent									

RTT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Window size									
Packet sent									



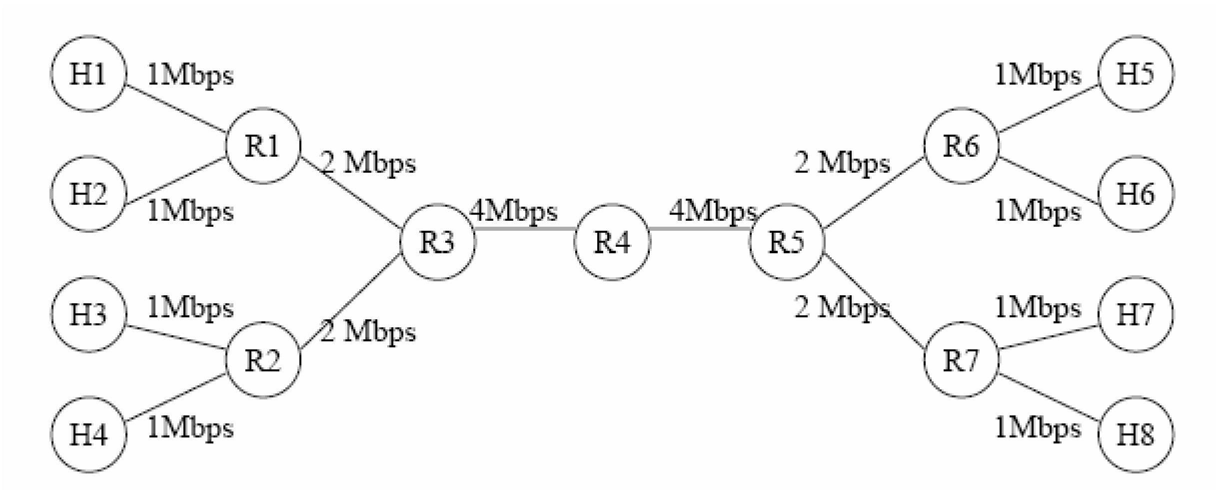
5. Congestion / Scheduling [10 points]

5.1) [5 points] Consider the network below, with eight hosts H1, .., H8, and seven routers R1, .., R7, each of which is much faster (in terms of processing) than any of the links. All links are full-duplex with bandwidths as shown in the figure. (A link is full-duplex if it allows that data be transmitted in both directions, at the same specified rate.) Answer the following:

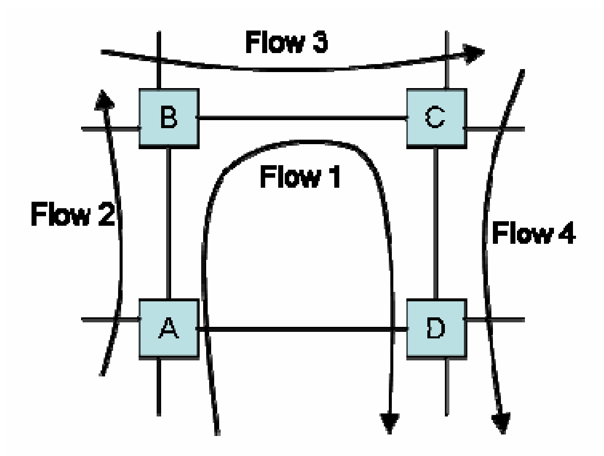
a) Which routers can never be congested?

b) Which routers are vulnerable to congestion?

For the routers that can get congested, show specific traffic patterns that could cause congestion.



5.2) [5 points] Consider the network below consisting of four routers. Every link has capacity of 1 Mbps, and every flow sends data at 1 Mbps. Assume that all flows are UDP and use the same packet size.



a) What is the throughput of each flow (i.e. actual rate at which packets of the given flow arrive at its respective destination), if all routers implement FIFO scheduling. FIFO scheduling implies that in the case of congestion, each packet is dropped with the same probability.

b) What is the throughput of each flow if all routers implement Weighted Fair Queueing, and each Flow i has weight i?

6. Multimedia [10 points]

6.1) [6 points] Recall the two FEC schemes for recovery of packet loss in multimedia applications: Redundant XOR-ing and Redundant Streaming. Suppose the first scheme generates a redundant chunk for every four original chunks. Suppose the second scheme uses a low-bit rate encoding whose transmission rate is 25 percent of the transmission rate of the nominal stream.

a) How much additional bandwidth does each scheme require?

b) How much playback delay does each scheme add?

c) How do the two schemes perform if the first packet is lost in every group of 5 packets? Which scheme will have better audio quality?

c) How do the two schemes perform if the first packet is lost in every group of 2 packets? Which scheme will have better audio quality?

6.2) [4 points] Suppose a server transmits one frame of a video every second, and the client starts playing the video at one frame per second as soon as the first frame arrives. Suppose the first ten frames arrive at times 0, 1.2, 1.99, 4.17, 4.01, 5.03, 8.05, 7.50, 8.90, 8.99, all in seconds.

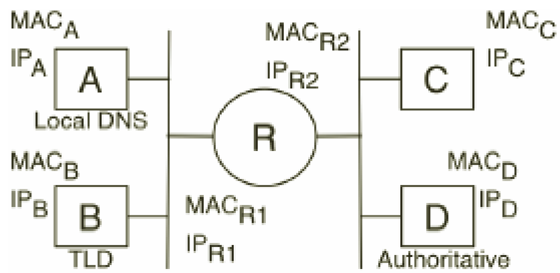
a) Which frames reach the client too late for playout?

b) How much extra playout delay is needed to ensure that all frames have arrived by the time the client needs to play them?

7. DNS and HTTP Potpourri [17 points]

7.1) [4 points] Consider the following network where Local DNS Server A receives a request to resolve host C's address. A already has the IP address of the appropriate (nearest) top-level DNS server (B) cached. The authoritative DNS server for C is D.

Circle R represents a router connecting two network segments. Router R has two NICs – one NIC (R_1) is connected to the left network, and the other NIC (R_2) is connected to the right network. Assume the Address Resolution Protocol (ARP) table at each host and router is pre-populated with the MAC and IP addresses of hosts in the same local area network. The MAC address and the IP address of any particular host X (i.e. NIC) are denoted as MAC_X and IP_X respectively.



Now, if B does not have a record for C, and it does NOT support DNS recursive queries, write down the sequence of Ethernet and IP frames (i.e. addresses) during the DNS lookup process by filling the following table. (The number of rows is not necessarily equal to the number of frames during the process.)

Frame Number	Source MAC address	Destination MAC address	Source IP address	Destination IP address
1				
2				
3				
4				
5				
6				
7				

7.2) [4 points] Repeat question (a) assuming B now supports DNS recursive queries.

Frame Number	Source MAC address	Destination MAC address	Source IP address	Destination IP address
1				
2				
3				
4				
5				
6				
7				

7.3) [4 points]

Suppose within your web browser you click on a link to obtain a web page. The IP address for the associated URL is not cached in your local host, so a DNS look up is necessary to obtain the given IP address. Further suppose that 3 DNS servers are visited before your host receives the IP address form DNS. The round trip time between the client and the i^{th} DNS server is T_i ($1 \le i \le 3$), and that between the j^{th} DNS server and the $(j+1)^{th}$ DNS server is t_j ($1 \le j \le 2$).

Further suppose that the page contains four objects (including the webpage) and that the web browser has to fetch the webpage (the .html file) before it knows 3 (other) image objects are contained in the webpage. Assume that it takes negligible time to transmit the .html file (i.e., the transmission time for the file is zero), but O_i time is required to transmit the i^{th} image object. Let T_0 denote the propagation delay (i.e., RTT excluding transmission time) between the local host and the server containing the objects.

How much time elapses from the time instant when the client clicks on the link until the time instant when the client receives a complete webpage? **Assume iterative DNS query service and persistent HTTP with pipelining.**

7.4) [5 points]

Repeat 7.3) but this time assuming that **recursive DNS query service and non-persistent HTTP with parallel connections** are used. (In case of parallel HTTP, the client establishes multiple TCP connections with the server in order to speed up the download of a particular web page.)

8. Security [18 points]

8.1) [10 points] Assume Alice wants to send confidential emails to Bob. K_B^+ and K_B^- are Bob's public and private keys; K_A^+ and K_A^- are Alice's public and private keys. For each of the following, discuss whether the given option provides sufficient message confidentiality, sender authenticity, and data integrity. I.e., in each case (a) to (e), circle the options that apply.

Note: When considering this problem, it is reasonable to assume that Alice will not send an email with the same content (i.e. she will not send the same M) twice.

a) Alice sends $[K_B^+(M), K_A^+(M)]$

- Message confidentiality
- Sender authenticity
- Data integrity

b) Alice sends $[K_B^+(M), K_A^-(K_B^+)]$

- Message confidentiality
- Sender authenticity
- Data integrity

c) Alice sends $[K_B^+(M), K_A^-(M)]$

- Message confidentiality
- Sender authenticity
- Data-integrity

d) Alice sends $[K_B^+(M), K_A^-(K_B^+(M))]$

- Message confidentiality
- Sender authenticity
- Data integrity

e) Alice sends $[K_B^+(M), K_A^+(K_B^+(M))]$

- Message confidentiality
- Sender authenticity
- Data integrity

8.2) [4 points] The software company PerfectSecurity is selling a new defence software against DDoS attacks. Their software looks at the source IP address of all incoming packets, and if it finds any IP address that accounts for more than 1% of overall traffic over the last hour, it installs an entry in the router that blocks all packets from that address for the next 24 hours. PerfectSecurity's marketing people are claiming that this will stop all DDoS attacks effectively.

(a) Name at least two reasons why PerfectSecurity's software is not a good solution to the problem?

(b) Explain how PerfectSecurity's solution could be mis-used (by a malicious third party) to prevent a legitimate user from accessing a web-site protected by their software.

8.3) [4 points] Suppose two directly connected routers A and B exchange their routing information by means of IP packets. A third party C, several hops away, could conceivably launch a denial-of-service attack on (e.g.) router B by sending unwanted packets to this router. To defend B from such attacks, the network operator might install a packet filter that discards all packets destined to B, except for packets sent from IP address A. However, as a countermeasure, C could now easily send "spoofed" packets to B, and get to place unwanted load on router B in spite of the presence of the packet filter.

Propose a measure that would effectively defend B against such (spoofed-packet) type of attacks by exclusively relying on the inherent features of IP protocol.

IP PACKET FORMAT: