City University of Hong Kong

Course code & title	:	EE3320 Internet Technologies & Protocols
Session	:	Semester B 2011/2012
Time allowed	:	Two hours

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1. This paper consists of 4 questions.
2. Answer **ALL** four questions.

Materials, aids & instruments permitted to be used during examination:

1. Non-programmable calculator

Do not take away the question paper after the examination!!

Question 1. **(25 marks)**

a. Suppose Alice, with a Web-based e-mail account (such as Hotmail), sends a message to Bob, who accesses his mail from his mail server using POP3. And, suppose Bob, with an Outlook e-mail account, returns a message to Alice, who accesses her mail from her mail server using IMAP. Discuss how the message gets from Bob's host to Alice's host. Be sure to list the series of application-layer protocols that are used to move the message between the two hosts. [3 marks]

b. In Web caching, "conditional GET" is used to update the cached object. If the cache sends an HTTP request with "If-modified-since: 1 May 2012 10:00pm", what is the condition that the cache gets the updated object. [2 marks]

c. Suppose an HTTP client wants to download three objects from a server. The sizes of the three objects are all smaller than the MSS (maximum segment size). The transmission times for the three objects are T_1, T_2, and T_3, respectively, and those of the control packets are negligible. Assume that the transmission is error free and loss free, and pipelining is not used. Let *RTT* be the round-trip time. Assume that the client opens a new TCP connection only after the last ACK is transmitted. [8 marks]

i. Draw a transmission figure to show how the client opens a connection, downloads the first object from the server, and closes the connection, assuming that HTTP with non-persistent connection is used. Indicate the exchange of all packets (including control packets) in the figure.
ii. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with non-persistent connection to download the three objects?
iii. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with persistent connection to download the three objects? Draw a figure to justify your answer.
iv. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with persistent connection and pipelining to download the three objects?

d. Consider Figure Q. 1, in which there is an institutional network connected to the Internet. Suppose that the average object size is 800,000 bits and that the average request rate from the institution's browsers to the origin servers is 5400 requests per hour. Also suppose that the amount of time it takes for the signal traveling from the router on the Internet side of the access link to the origin servers and coming back is three seconds on average. Model the total average response time as the sum of the average access delay (that is, the delay from the Internet router to the institution router) and the average Internet delay. For the average access delay, use $T/(1-TB)$, where T 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.

i. Find the total average response time. [4 marks]

ii. Now suppose a cache is installed in the institutional LAN. Suppose that the hit rate is 0.3. Find the total average response time. [4 marks]

iii. What is the total average response time if we upgrade the access link with two parallel links, each with 5 Mbps, instead of installing a cache in the institutional LAN? Assume that the traffic is evenly distributed on the two links. If the speed of the access link can be further increased, what is the minimum possible value for the total average response time? [4 marks]

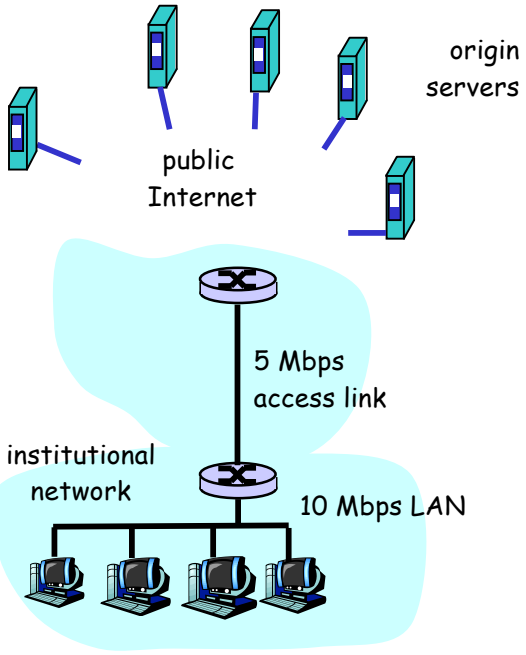


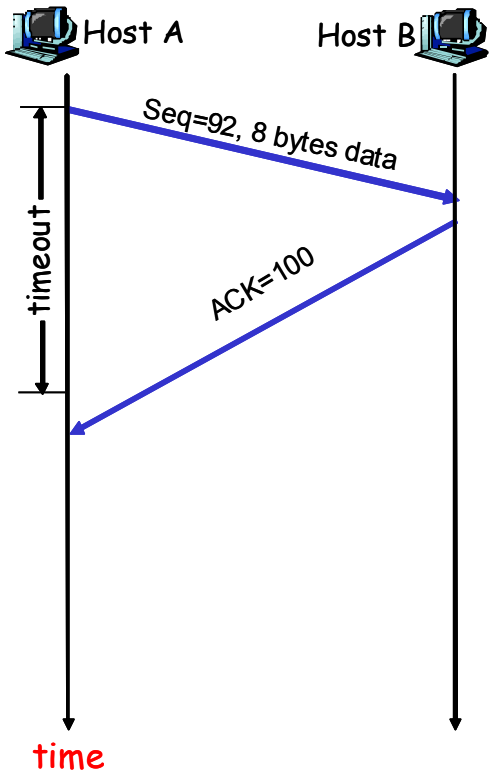
Figure Q.1

Question 2. **(25 marks)**

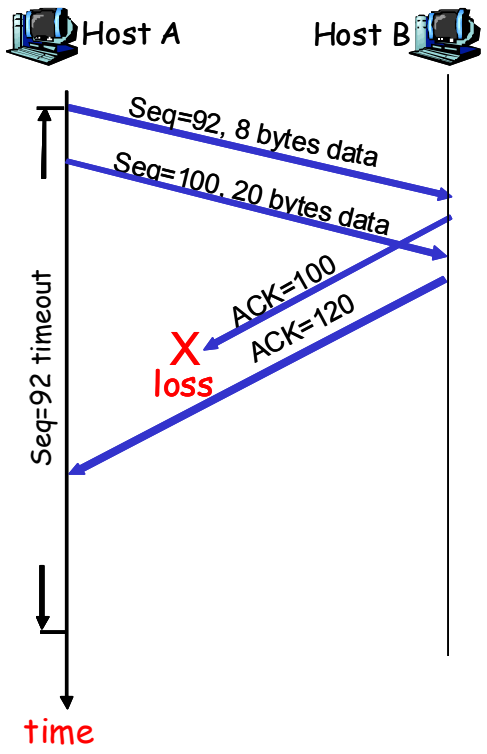
a. Suppose that the round trip time between the sender and the receiver is constant and known to the sender. Would a timer still be necessary in TCP if packets cannot be lost? Explain. [4 marks]

b. Describe why an application developer might choose to run an application over UDP rather than TCP. [3 marks]

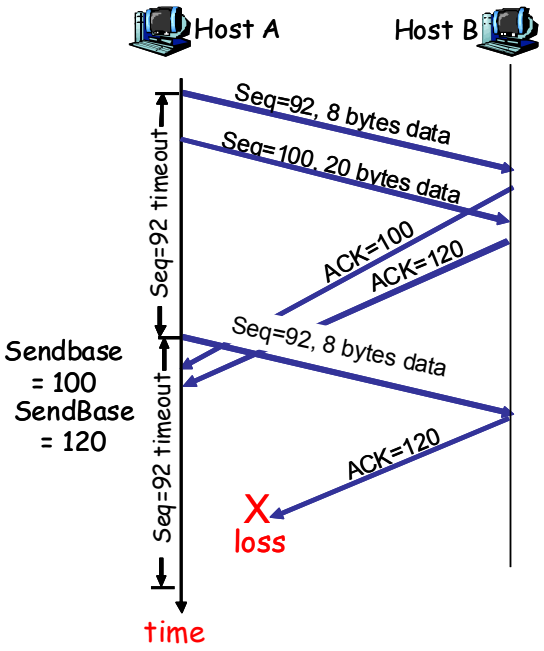
c. After Host A reaches the expected timeout limit in the following four situations, describe whether Host A will retransmit the segment(s) or not and the reason behind. [6 marks]


Host A
Host B
Seq=92, 8 bytes data
timeout
ACK=100
time

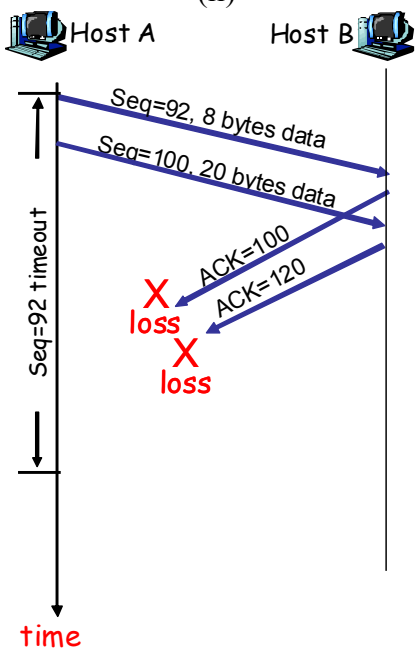
(i)


Host A
Host B
Seq=92, 8 bytes data
Seq=100, 20 bytes data
ACK=100
ACK=120
X
loss
Seq=92 timeout
time

(ii)


Host A
Host B
Seq=92, 8 bytes data
Seq=100, 20 bytes data
Seq=92 timeout
ACK=100
ACK=120
Sendbase
= 100
SendBase
= 120
Seq=92, 8 bytes data
Seq=92 timeout
ACK=120
X
loss
time

(iii)


Host A
Host B
Seq=92, 8 bytes data
Seq=100, 20 bytes data
Seq=92 timeout
ACK=100
ACK=120
X
loss
X
loss
time

(iv)

d. Assuming TCP Reno is the protocol experiencing the behavior shown in Table 1, answer the following questions. In all cases, you should provide a short explanation justifying your answer. [12 marks]

Table 1: TCP congestion control

NTR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CWS	8	9	10	11	12	6	7	8	9	10	1	2	4	5	6	3

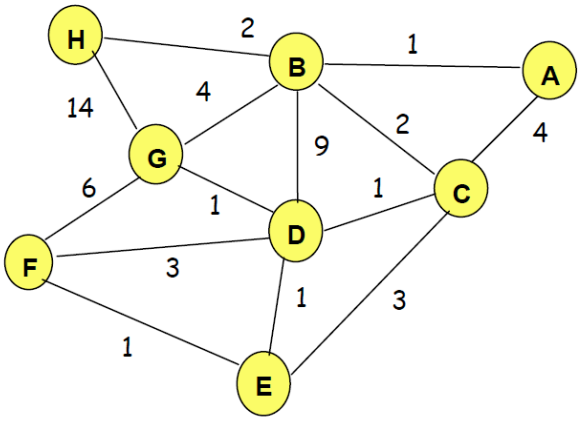
NTR – number of transmission round (note that transmission round has been renumbered)

CWS – congestion window size

i. Identify the intervals of time when TCP slow start is operating.
ii. Identify the intervals of time when TCP congestion avoidance is operating.
iii. After the 5th transmission round, by which way is segment loss detected?
iv. After the 10th transmission round, by which way is segment loss detected?
v. What is the maximum possible initial value of Threshold at the first transmission round?
vi. What is the value of Threshold at the 6th transmission round?
vii. What is the value of Threshold at the 10th transmission round?
viii. What would be the congestion window size and the value of Threshold if the segment loss at the 16th transmission round is not due to timeout?

Question 3. **(25 marks)**

a. Consider the following network: [8 marks]



If the cost between Node F and Node G becomes one, using Dijkstra's algorithm, compute the shortest path from **Node E** to all network nodes. Use the table form below but work out the results in your answer book. If there is a tie, ***break it in favor of rightmost column***.

- $D(v)$: cost of the least-cost path from source to destination v.
- $P(v)$: previous node (neighbour of v) along the current least-cost path
- N: v is in N if the least-cost path from source to v is known.

N	A	B	C	D	F	G	H

b. In Figure Q.3b, we assume that A,B,C are provider networks and X,W,Y are customers of provider networks. In addition, Border Gateway Protocol (BGP) is assumed to be used between networks. State whether the following statements are true or false. Explain your answer. [4 marks]

i. X is willing to advertise to B a route to C.
ii. A is willing to advertise to B the path AW
iii. B is willing to advertise to X the path BAW
iv. B is willing to advertise to C the path BAW

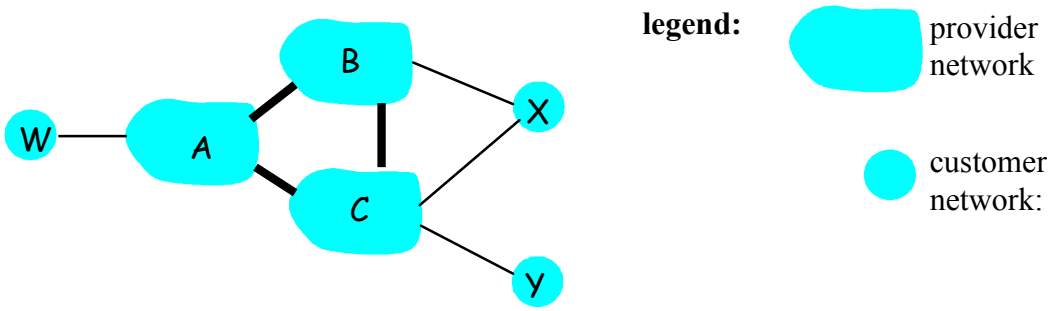


Figure Q3.b: A simple BGP scenario

c. In Figure Q.3c, assume that link AC has gone down for a long time. If B, C and D use split horizon with Poisoned Reverse. [13 marks]

i. What distance to A will D report to C?
ii. What distance to A will C report to D?
iii. What distance to A will B report to C?
iv. What distance to A will C report to B?

Now, suppose the AB link goes down.

v. What distance to A will B report to D?
vi. At the same time, what distance to A will D report to B?
vii. At the same time, what is the distance to A that C reports to D?
viii. At the same time, what is the distance to A that C reports to B?
ix. What does D then think the shortest path to A is?
x. What does D then tell C about its distance to A?
xi. What does D then tell B about its distance to A?
xii. What is B's route to A now?
xiii. What does B then tell C the distance to A?

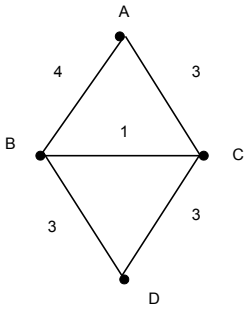


Figure Q.3c

Question 4. **(25 marks)**

a. Consider the MPLS network shown in Figure Q. 4. [15 marks]

i. Describe how the Ingress Label Switching Router in an MPLS domain handles an arriving IP packet.

ii. Suppose that a packet with destination address 128.89.24.5 enters the MPLS network from the left. Draw down how the packet goes through the network.

iii. Suppose that we want to perform flow aggregation so that packets with destination network address 117.59.0.0 will join the same class of the packets with destination network address 128.89.0.0. Write down the three modified tables which would make this possible.

iv. Suppose that another packet with destination address 117.59.25.4 enters the MPLS network from the left after flow aggregation mentioned in iii). Draw down how the packet goes through the network.

v. Suppose that we want to perform traffic engineering in the MPLS network in iv) so that packets with destination address 171.69.13.9 will now go the upper path of the network and perform flow aggregation and join the same class of the packets with destination network address 117.59.0.0. Write down the three modified tables which would make this possible.

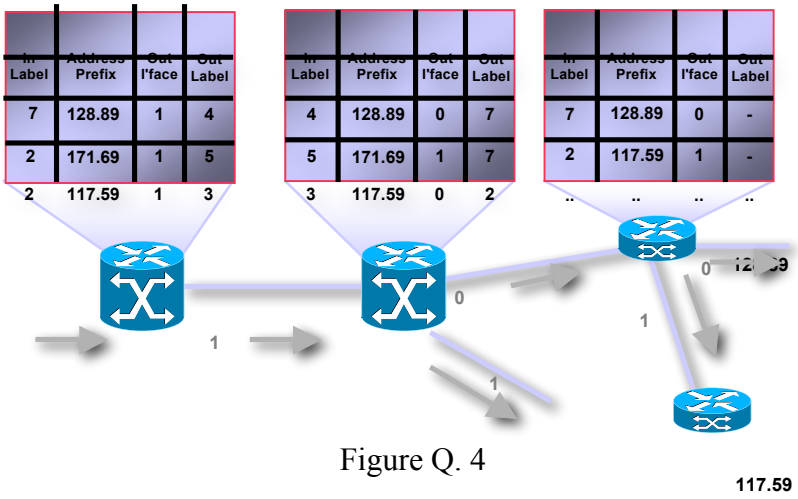


Figure Q. 4

b. Usually, the label needs to be removed one hop prior to de-aggregation point for the case of label sharing in MPLS. In what situation is this prior label removing unnecessary? [4 marks]

c. What actions will be taken for out-of-profile packets in DiffServ? How do these actions affect the out-of-profile packets accordingly? [6 marks]

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