City University of Hong Kong

Course code & title	:	EE3320 Internet Technologies & Protocols
Session	:	Semester B 2010/2011
Time allowed	:	Two hours

This paper consists of 4 questions.

1. Answer **ALL** four questions.

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

1. Non-programmable calculator

Question 1. **(25 marks)**

(a) Suppose within your web browser you click on a link to obtain a web page. Suppose that web page associated with the link contains a small amount of HTML text. Let RTT denote the round trip time between the local host and the server containing the HTML file. Further suppose the page references nine objects each with size L and the transmission rate R. Assuming zero queueing time of the objects, how much time is needed from when the client clicks on the link until the client receives all the nine referenced objects with

i) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to two? [2 marks]

ii) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to four? [2 marks]

iii) non-persistent HTTP with no parallel connections? [2 marks]

vi) persistent HTTP with pipelining? [2 marks]

v) persistent HTTP without pipelining? [2 marks]

(b) Consider Figure Q. 1, in which there is an institutional network connected to the Internet. Suppose that the average object size is 900,000 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 between the router on the Internet side of the access link and the origin servers 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. [5 marks]

ii) Now suppose a cache is installed in the institutional LAN. Suppose that the miss rate is 0.4. Find the total average response time. [5 marks]

iii) What is the total average response time if we upgrade the access link to the speed of 6 Mbps instead of installing a cache in the institutional LAN? If the speed of the access link can be further increased, what is the minimum possible value for the total average response time? [5 marks]

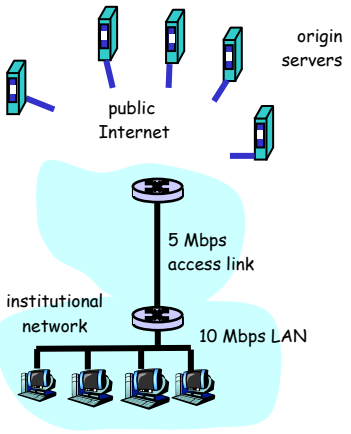


Figure Q.1

Question 2. **(25 marks)**

(a) With reference to Fig. Q. 2 showing TCP disconnection procedure, when TCP receives a FIN from the other TCP, TCP needs to go through two wait states (CLOSE WAIT and LAST ACK) before closing the connection. Please answer the following:

i) What may go wrong if Site 2 sends "FIN seq=y, ACK x+1" earlier? [2 marks]
ii) What is the advantage for Site 2 sending "ACK x+1" before sending "FIN seq=y, ACK x+1"? [2 marks]
iii) How will Site 2 be affected if "FIN seq=x" from Site 1 is lost? [2 marks]
iv) How will Site 1 be affected if "FIN seq=x" from Site 1 is lost? [2 marks]
v) What is the difference if Site 2 sends "FIN seq=y" instead of "FIN seq=y, ACK x+1"? [2 marks]

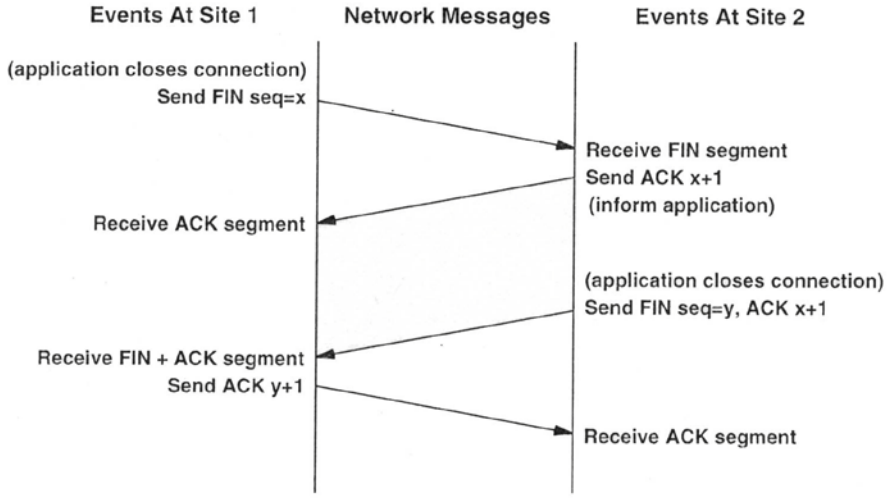


Figure Q. 2

(b) A TCP opens a connection and uses slow start. Assume that the maximum window size is 50 and the window threshold is 16.

i) Approximately how many round-trip times are required before TCP can send 16 and 30 segments, (i.e. window size = 16 and 30), respectively? [8 marks]

ii) What does TCP respond for congestion control if a segment is lost at the round-trip times equal to 20? [3 marks]

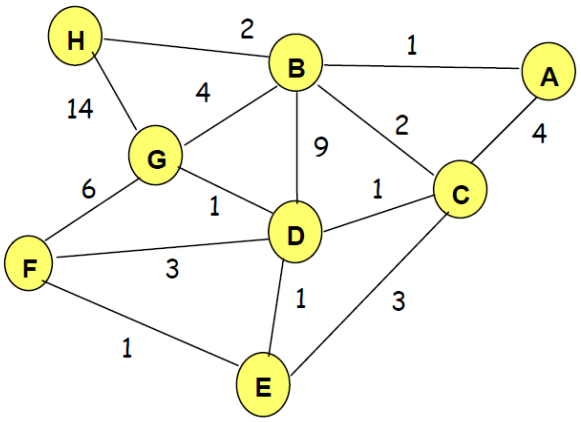
(c) In this problem we consider the delay introduced by the TCP slow-start phase. Consider a client and a Web server directly connected by one link of rate *R*. Suppose the client wants to retrieve an object whose size is exactly equal to 13*S*, where *S* is the maximum segment size (MSS). Denote the round-trip time between client and server as RTT (assume to be constant). Ignoring protocol headers, determine the time to retrieve the object (**including** TCP connection establishment) when

i) 3 S/R > RTT > S/R, [2 marks]

ii) 5 S/R > RTT > 3 S/R. [2 marks]

Question 3. **(25 marks)**

(a) Consider the following network: [10 marks]



Using Dijkstra's algorithm, compute the shortest path from **Node G** 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 leftmost 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	E	F	H

(b) Consider a subnet with routers *A*, *B*, *C*, *D*, and *E*, distance vector routing is used; and the following vectors have just come in to router *C*: from *A* indicating the delay to routers *A*, *B*, *C*, *D*, and *E*: (0,6,3,2,4); from *B*: (6,0,8,11,6); from *D*: (16,2,6,0,7); and from *E*: (8,6,3,4,0). The measured delays from router *C* to its neighbours *A*, *B*, *D*, and *E*, are 3, 2, 3, and 5, respectively. Assume that *C*'s original routing table indicating the delay to routers *A*, *B*, *C*, *D*, and *E* (1,7,0,4,4) and the next routers to be used (*A*, *B*, –, *D*, *A*). What is *C*'s new routing table? Give both the next router to be used and the expected delay. [7 marks]

(c) Consider the Vector-Distance update shown in the Fig. Q. 3 below. It shows an existing table i) in a gateway K, and update message ii) from another gateway J. Write down the changes in the table and give the reasons for those changes. Assume that the distance between gateway K and J is 2. [8 marks]

Destination	Distance	Route
Net 1	0	Direct
Net 2	0	Direct
Net 4	8	Gate L
Net 17	4	Gate M
Net 24	5	Gate J
Net 30	10	Gate Q
Net 42	4	Gate J

i) An existing routing table for a gateway K

Destination	Distance
Net 1	2
Net 4	2
Net 17	1
Net 24	4
Net 30	12
Net 40	4
Net 42	2

ii) An incoming routing update message from gateway J.

Figure Q. 3

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 128.89.0.0 will 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.

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 shown 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.

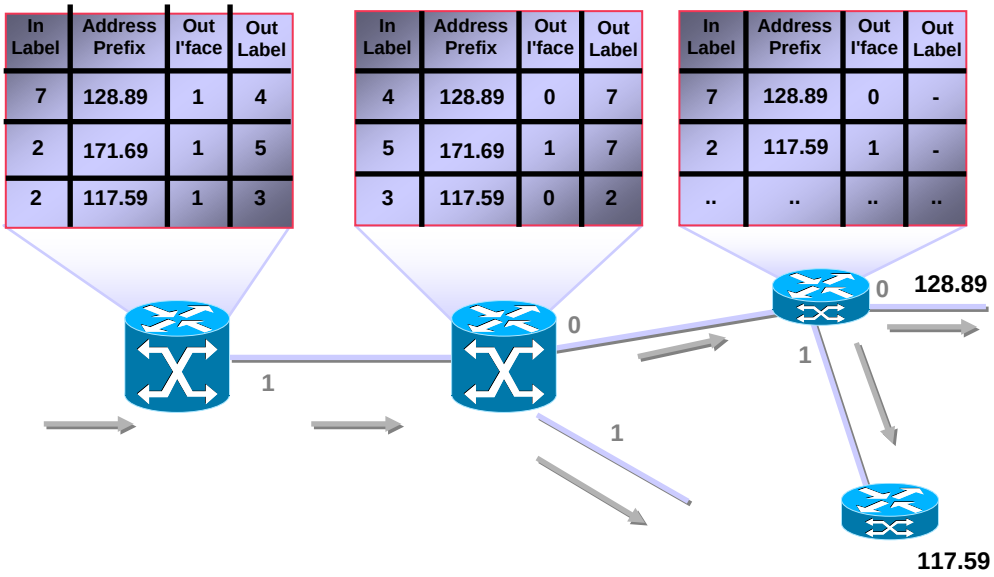


Figure Q. 4

(b) With the help of a diagram, show how to use "Token Bucket" to limit packets input into the network to specified Burst Size and Average Rate. [6 marks]

(c) Define how to use the Diffserv concept to manage the flow traffic in the Edge router and the Core router. [4 marks]

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