City University of Hong Kong

Course code & title	:	EE3315 Internet Technology
Session	:	Semester B 2013/2014
Time allowed	:	Two hours

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

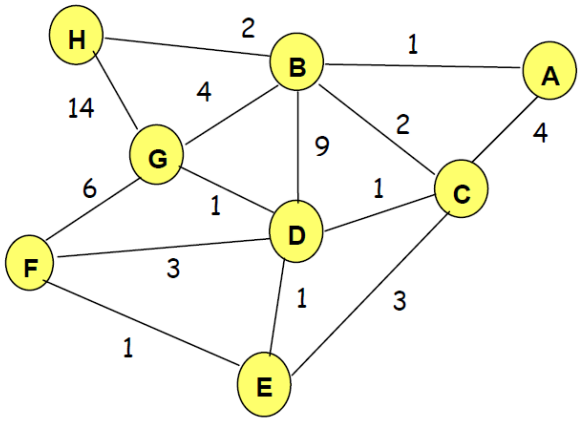
Materials, aids & instruments permitted to be used during examination:

1. Approved calculator

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

Question 1. **(25 marks)**

a. Consider the following network: [8 marks]



Say that the number on every link represents the cost of using this link. If **the cost of using the link between Node E and Node F is changed from 1 to 2**, 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 sheet. If there is a tie, ***break it in favor of rightmost column***. List out all the shortest paths from Node E to all the other nodes.

N	A	B	C	D	F	G	H

b. Consider the Distance-Vector update shown in the Fig. Q.1b 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 gateways K and J is 3. [4 marks]

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

Figure Q.1b (i)An existing routing table for a gateway K

Destination	Distance
Net 1	2
Net 4	8
Net 17	2
Net 18	4
Net 24	3
Net 30	8
Net 42	2

Figure Q.1b (ii) An incoming routing update message from gateway J.

c. In Figure Q.1c, assume that link CD has gone down for a long time. Assume A, B and D use split horizon with Poisoned Reverse. [13 marks]

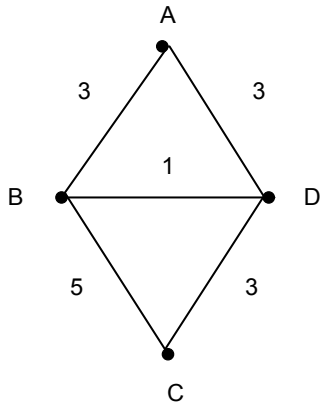


Figure Q.1c

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

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

Question 2. **(25 marks)**

a. In Figure Q.2a, 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 used between networks. State whether the following statements are true or false. Explain your answer. [4 marks]

i) W is willing to advertise to C a route to B.
ii) A is willing to advertise to C the path AX
iii) C is willing to advertise to W the path CAX
iv) C is willing to advertise to B the path CAX

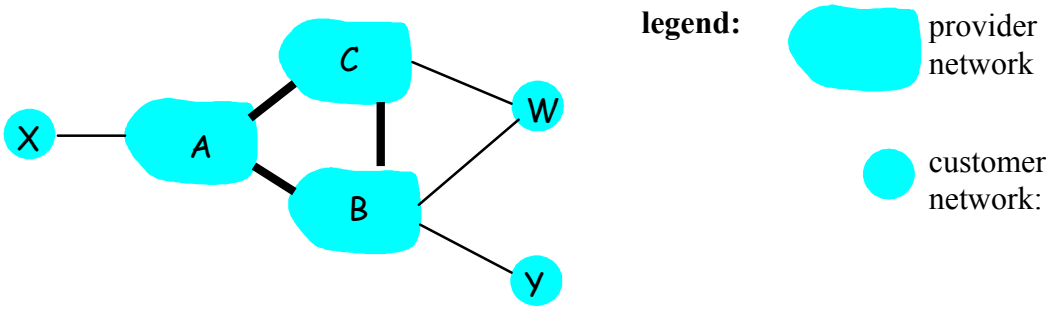


Figure Q.2a : A simple BGP scenario

b. A TCP source opens a connection and uses slow start. Assume that the maximum window size is 50 and the window threshold is 4.

i) Approximately how many round-trip times are required before TCP can send 16 and 32 segments, (i.e. window size = 16 and 32), respectively? [6 marks]
ii) What does TCP respond for congestion control if a segment is lost at the round-trip times equal to 26? [3 marks]

c. 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	28	29	30	31	32	16	17	18	19	20	1	2	4	8	1	2

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 11th transmission round?

viii. What will be the congestion window size and the value of Threshold at the 17th transmission round if a segment is lost after the 18th transmission round due to a triple duplicate ACK?

Question 3. **(25 marks)**

a. 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 2014 10:00pm", what is the condition that the cache gets the updated object. [3 marks]

b. Suppose that 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 that the page references thirteen 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 thirteen referenced objects with

i) persistent HTTP with pipelining? [2 marks]
ii) persistent HTTP without pipelining? [2 marks]
iii) non-persistent HTTP with no parallel connections? [2 marks]
iv) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to two? [2 marks]
v) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to four? [2 marks]

c. Consider Figure Q.3c, in which there is an institutional network connected to the Internet. Suppose that the average object size is 600,000 bits and that the average request rate from the institution's browsers to the origin servers is 2200 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 four 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 four parallel links, each with 10 Mbps, instead of installing a cache in the institutional LAN? Assume that the traffic is evenly distributed on the four links. [4 marks]

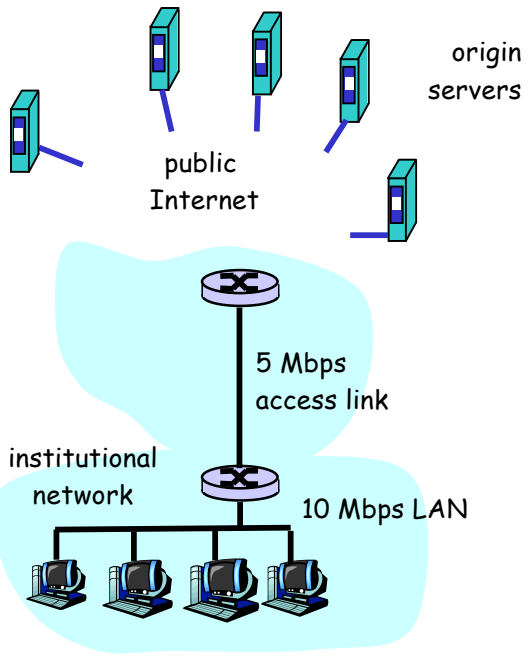


Figure Q.3c

Question 4. **(25 marks)**

a. 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]

b. 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 $14S$, 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 $6\ S/R > S/R + RTT > 2\ S/R$. [6 marks]

c. Consider Figure Q.4c, which shows a token bucket policer being fed by a stream of packets. The token buffer can hold at most one token, and is initially full at $t = 0$. New tokens arrive at a rate of two tokens per slot. The output link speed is such that if two packets obtain tokens at the beginning of a time slot, they can both go to the output link in the same slot. The timing details of the system are as follows: [9 marks]

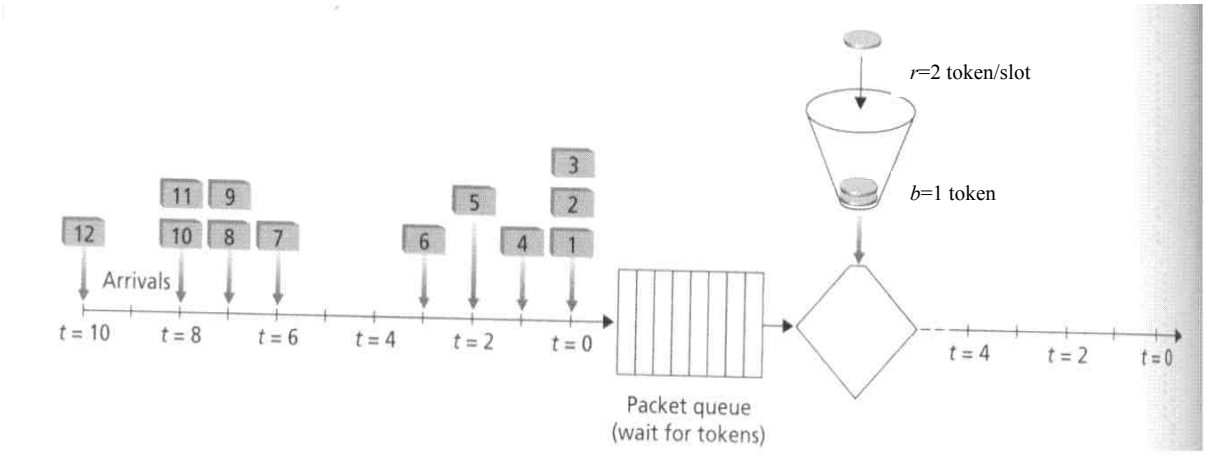


Figure Q.4c

1) Packets (if any) arrive at the beginning of the slot. Thus in the figure, packets 1, 2 and 3 arrive in slot 0. If there are already packets in the queue, then the arriving packets join the end of the queue. Packets proceed towards the front of the queue in a FIFO manner.
2) After the arrivals have been added to the queue, if there are any queued packets, one or two of those packets (depending on the number of available tokens) will each remove a token from the token buffer and go to the output link during that slot. Thus, packet 1 removes a token from the buffer (since there is initially one token) and go to the output link during slot 0.
3) Tokens are added to the token buffer as long as it is not full. The token generation rate is $r = 2$ token/slot. If a token is generated and the buffer is full, the token is discarded.
4) Time then advances to the next time slot, and these steps are repeated.

Answer the following questions:

i. For each time slot, identify the packets that are in the queue and the number of tokens in the bucket, immediately after the arrivals have been processed (step 1 above) but before any of packets have passed through the queue and removed a token. Thus, for the $t = 0$ time-slot in the example above, packets 1, 2 and 3 are in the queue, and there is one token in the buffer.
ii. For each time slot, indicate which packets appear on the output after the token(s) have been removed from the queue. Thus, for the $t = 0$ time-slot in the example above, packet 1 appears on the output link from the token bucket during slot 0 (the $t = 0$ time-slot).

d. With the help of a plot, explain how TCP achives fairness using "additive increase" and "multiplicative decrease" with two competing sessions? [4 marks]

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