National University of Computer & Emerging Sciences, Karachi

FAST School of Computing

Midterm I Examination, Spring 2021

19th March 2021, 11:00 pm – 12:00 pm

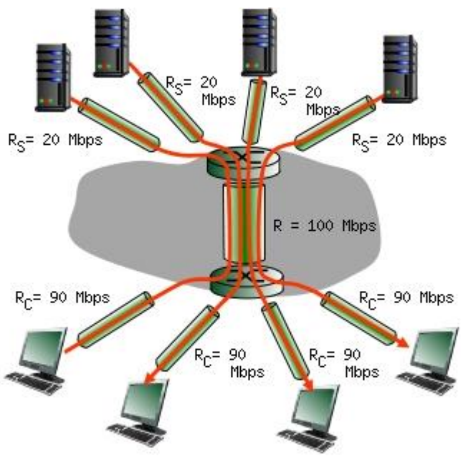
Course Code: CS-307	**Course Name: Computer Networks**
Instructor Names: Dr. Sufian Hameed, Dr. Nadeem Kafi, Dr. Hassan Jamil, Dr. Aqsa Aslam, Mr. Shoaib Raza, Mr. Abdullah Zarshaid	
Student Roll No:	**Section No:**

Instructions:

- Return the question paper.
- **All questions must be answered in the answer script and according to the sequence given in the question paper.**
- All question carry equal marks.
- In case of any ambiguity, you may make an assumption. But your assumption should not contradict any statement in the question paper.

Time: 60 minutes. **Max Marks**: 60 points

Question 1: Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 100 Mbps. The four links from the servers to the shared link have a transmission capacity of R_S = 20 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 90 Mbps per second. You might want to review Figure 1.20 in the text before answering the following questions:



a) What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fair-shared (i.e., divides its transmission rate equally among the four pairs)?

b) Which link is the bottleneck link for each session?

c) Assuming that the senders are sending at the maximum rate possible, what are the link utilizations for the sender links (R_S), client links (R_C), and the middle link (R)?

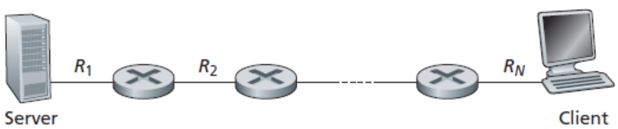
Answer:

a) The maximum achievable end-end-throughput is 20 Mbps.

b) This is the transmission capacity of the first hop, which is the bottleneck link since the first-hop transmission capacity of 20 Mbps is less than one-quarter of the shared-link transmission capacity (100/4 = 25 Mbps) and less than the third-hop transmission capacity of 90 Mbps.

c) The utilization of sender links is 100%. The utilization of receiver links is 22.22%. The utilization of the middle link is 80%.

Question 2: Consider the network setup is shown with two end-hosts and three routers R1, R2, and R3 (i.e. N=3). Now suppose that the web server sends 20 HTTP responses each of size 20K to the client. Assume any missing values but do explicitly mention them as part of your answer.



a) How many TCP connections will be created for exchanging 20 responses?

b) How many times the transport layers will be activated? And where?

c) How many times network and data link layers will be activated? And where?

d) Write the name and type of physical mediums of each link shown.

Answer:

a) <u>V1.0:</u> 20 TCP connections. <u>V1.1:</u> Server can send many responses on a single TCP connection.

b) At-least 20 times transport layer activations at both end-hosts i.e. Server and Client. (Assumption: segment size > 20K, therefore only one segment)

c) Network and Datalink layers traversed at Server, R1, R2, R3 and Client. 20 TCP segments will pass at each layer (Assumption: each TCP segment completely encapsulated in one L3 packet and the IP packet completely sits inside an L2 frame).

d) The diagram shows wired connections. The connection between Server-R1 and R3-Client could be Ethernet (any speed), Connection between R1-R2 and R2-R3 could be any ground, wireless, satellite link.

Comments in blue are for our understanding and should not be expected from the students. Students haven't learned intimate details of Layer 3 and Layer 4 processing as yet.

<u>Question 3:</u> Suppose that Alice as a client wants to retrieve the www.google.com home page but has no information about the www.google.com web server IP address:

(a) Describe the process of the Alice client obtaining the IP address for the hostname www.google.com under the assumption that it is not cached at the local DNS server and that the local DNS server has not cached an entry for the .com DNS server. (Describe this for the non-recursive case)
(b) What transport protocol(s) does DNS use: TCP, UDP, or Both?
(c) How many types of Resource Records (RR) are there?
(d) Is it possible for an organization's Web server and mail server to have the same alias for a hostname (for example, foo.com)? What would be the type of RR that contains the hostname of the mail server?

Answer:

(a) Client contacts local DNS, local DNS contacts root DNS, gets info on *.com DNS* back. Local DNS contacts *.com DNS* gets IP for www.google.com.
(b) DNS generally uses UDP, but in some cases (such as zone transfer) it will use TCP, so the answer is: Both.
(c) There are 4 types of RR's: A, CNAME, NS, and MX.
(d) Yes, an organization's mail server and Web server can have the same alias for a hostname. The MX record is used to map the mail server's hostname to its IP address

<u>Question 4:</u> Suppose Alice, with a Web-based e-mail account (such as Hotmail or Gmail), sends a message to Bob, who accesses his mail from his mail server using IMAP. Discuss how the message gets from Alice's host to Bob's host. Be sure to list the series of application-layer protocols that are used to move the message between the two hosts.

Answers: Message is sent from Alice's host to her mail server over HTTP. Alice's mail server then sends the message to Bob's mail server over SMTP. Bob then transfers the message from his mail server to his host over IMAP.

<u>Question 5:</u> The text below shows the reply sent from the server in response to the HTTP GET message. Answer the following questions, indicating where in the message below you find the answer.

HTTP/1.1 200 OK<cr><lf>Date: Tue, 07 Mar 2008 12:39:45GMT<cr><lf>Server: Apache/2.0.52 (Fedora) <cr><lf>Last-Modified: Sat, 10 Dec2005 18:27:46 GMT<cr><lf>ETag: "526c3-f228a4c80"<cr><lf>Accept-Ranges: bytes<cr><lf>Content-Length: 3874<cr><lf>Keep-Alive: timeout=max=100<cr><lf>Connection: Keep-Alive<cr><lf>Content-Type: text/html; charset=ISO-8859-1<cr><lf><cr><lf><!doctype html public "-//w3c//dtd html 4.0 transitional//en"><lf><html><lf><head><lf> <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1"><lf> <metaname="GENERATOR" content="Mozilla/4.79 [en] (Windows NT5.0; U) Netscape]"><lf>

<title>CMPSCI 453 / 591 / NTU-ST550A Spring 2005 homepage</title><*lf*></head><*lf*><*much more document text following here (not shown)*>

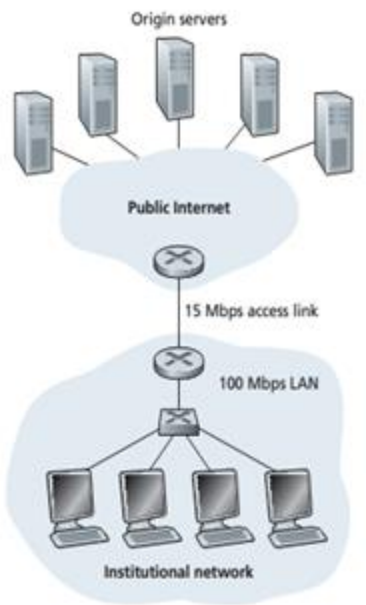
a) Was the server able to successfully find the document or not? What time was the document reply provided?
b) When the document was last modified?
c) How many bytes are there in the document being returned?
d) What are the first 5 bytes of the document being returned? Did the server agree to a persistent connection?

ANSWERS

a) The status code of 200 and the phrase OK indicate that the server was able to locate the document successfully. The reply was provided on Tuesday, 07 Mar 2006 12:39:45 Greenwich Mean Time.
b) The document index.html was last modified on Saturday 10 Dec 2005 at 18:27:46 GMT.
c) There are 3874 bytes in the document being returned.
d) The first five bytes of the returned document are <!doc. The server agreed to a persistent connection, as indicated by the Connection: Keep-Alive field

Question 6: Consider the scenario in the figure below, for which there is an institutional network connected to the Internet. Suppose that the average object size is 850,000 bits and that the average request rate from the institution's browsers to the origin servers is 16 requests per second. Also, suppose that the amount of time it takes from when the router on the Internet site of the access link forwards an HTTP request until it receives the response is three seconds on average. Model the total average response time as the sum of the average access delay (that is, the delay from Internet router to institution router) and the average Internet delay. For the average access delay, use $\Delta/(1 - \Delta\beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.

(a) Find the total average response time.
(b) Now suppose a cache is installed in the institutional LAN. Suppose the miss rate is 0.4. Find the total response time.



Answer:

(a) The total average response time is the sum of the average access delay (that is, the delay from Internet router to institution router) and the average Internet delay i.e. 3 seconds

The average access delay is modelled = $\frac{\Delta}{1-\Delta\beta}$

Where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link i.e. 16 requests/second.

To calculate **Δ**,

The average size of object = 850000 bits

The transmission rate of link= 15Mbp

$$\Delta = \frac{L}{R}$$

Δ = (850,000 bits)/(15,000,000 bits/sec) = 0.0567 sec
The traffic intensity on the link = $\Delta\beta$ = (16 requests/sec)(0.0567 sec/request) = 0.907
The average access delay = $\Delta/(1 - \Delta\beta)$ = (0.0567 sec)/(1 – 0.907) = 0.6 sec

The total average response time is therefore 0.6 sec + 3 sec = 3.6 sec

(b) Since 60% of requests are cache hits, i.e. the response is satisfied from within the institutional servers, the **traffic intensity or $\Delta\beta$** reduces by 60%. This means only 40% of the requests are required to go on the internet as they are cache misses.

Therefore the new traffic intensity is: $40/100 \times (16 \times 0.0567) = 0.36288$

The average access delay is: (0.0567 sec)/(1 – 0.36288) = 0 .089 sec

And, total average response time FOR CACHE MISSES: 3 + 0.089 = 3.089 sec

Since there is a 0.6 probability of cache hit which means response time is almost 0 seconds, and a 0.4 probability of utilizing a 3.089 response time

Hence the Total Average Response Time is: 0.6(0) + 0.4(3.089) = 1.24 sec

Thus the average response time is reduced from 3.61 sec to 1.24 sec when using the cache option.

BEST OF LUCK!