Question 1 [15 Marks]

Please consult the textbook

Question 2 [15 Marks]

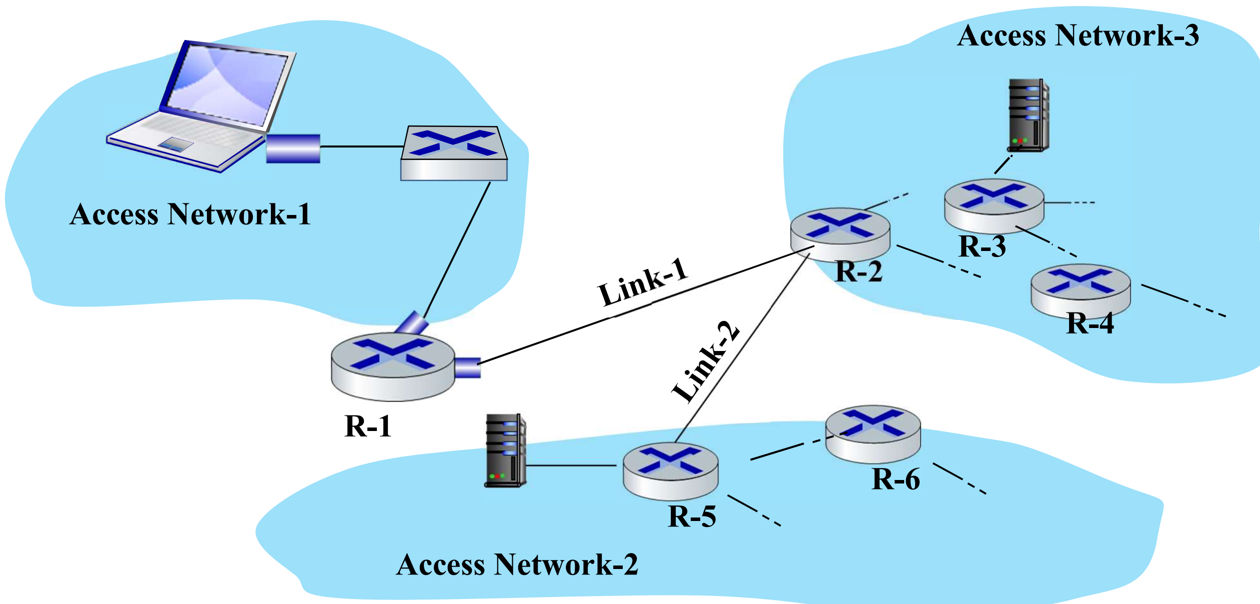


Figure 1

Consider Figure 1 with Link-1 between Router R-1 and Router R-2 having the distance d = 2 km and propagation speed s = 2×10^8 m/s. Router R-1 transmits packet of size L = 11,000 bits to Router R-2 at a rate of R = 100 Mbps.

a. Calculate the propagation delay (d_{prop}) experienced by the packet between R-1 and R-2. **[3]**

$$D_{prop} = \frac{d}{s} = \frac{2 \times 10^3}{3 \times 10^8} = \frac{20}{3} \times 10^{-6} = 6.67\ \mu s$$

b. Calculate the transmission delay (d_{trans}), for the packet transmitted by R-1. **[3]**

$$D_{trans} = \frac{L}{R} = \frac{11000}{100} \times 10^{-6} = 110\ \mu s$$

c. Calculate the total time elapsed since a single packet starts to be transmitted at R-1 until it is completely received at Router R-2. **[4]**

$$D_{total\_time\_elapsed} = D_{trans} + D_{prop} = 110 + 6.67 = 116.67\ \mu s$$

d. How long does it take by a packet of length 1000 bytes to propagate over the Link-2 from Router R-2 to Router R-5 of distance 2,500 km, propagation speed 2×10^8 m/s, and transmission rate of 2 Mbps? **[3]**

Propagation delay=

$$D_{prop} = \frac{d}{s} = \frac{2500 \times 10^3}{2 \times 10^8} = .0125s = 12.5ms$$

[3 marks for the correct equation and answer. If the answer is wrong but the equation is correct then 2 marks]

This is propagation delay and not transmission delay

- If a student also calculates the transmission delay, then also only 2 marks

e. Does the delay in part (d) depend on packet length? **[1]**

If equation in (part d) is wrong but (e) or (f) are correct then the response will be considered wrong.

Dose this delay depend on packet length? No

f. Does the delay in part (d) depend on transmission rate? **[1]**

If equation in (part d) is wrong but (e) or (f) are correct then the response will be considered wrong.

Does this delay depend on transmission rate? No

Question 3 [5 Marks]

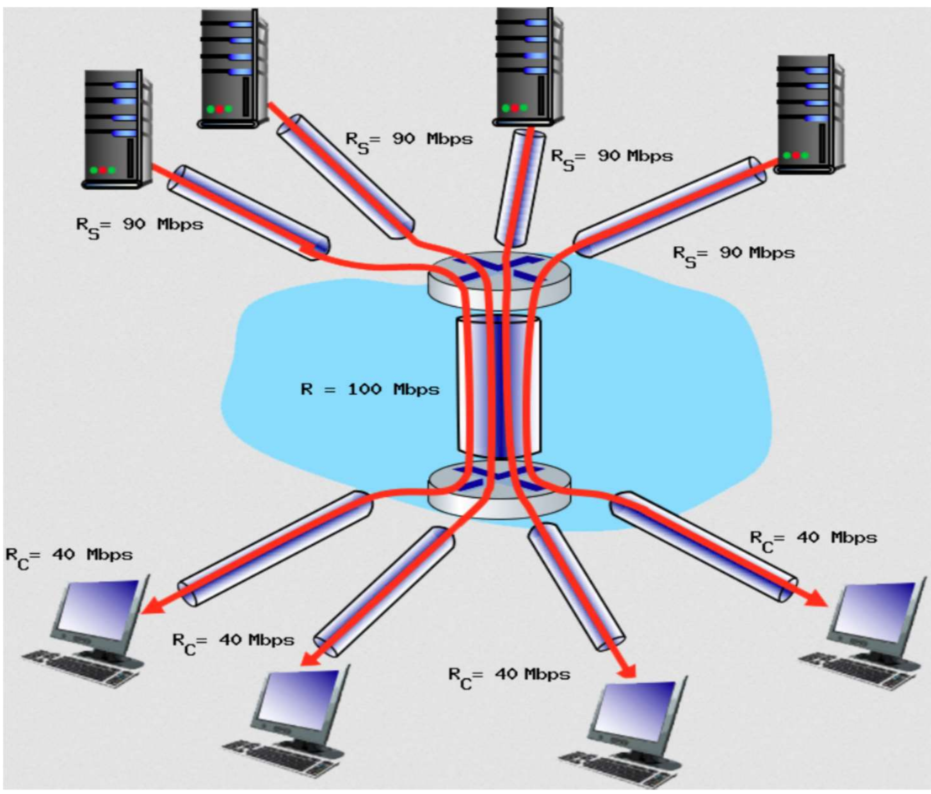


Figure 2

Consider the scenario shown in Figure 2, 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 = 90 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 40 Mbps.

a. What is the maximum achievable end-to-end throughput (in Mbps) for each of the four client-to-server pairs, assuming that the middle link is fairly shared (divides its transmission rate equally)? **[1]**

25 Mbps

b. Which link is the bottleneck link? R_C, R_S, or R. **[1]**

R

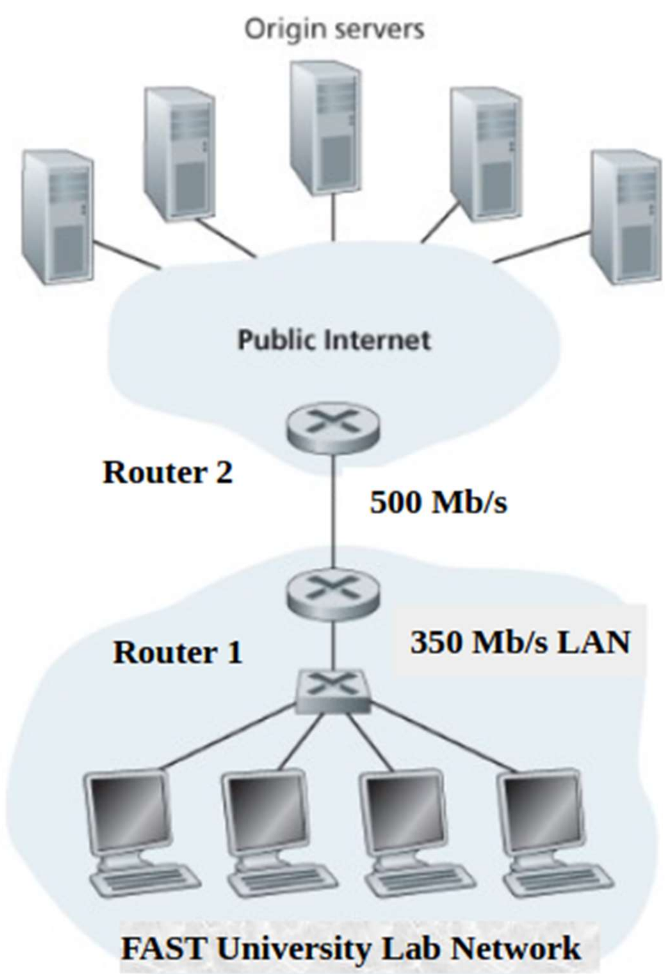
c. Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the server links (R_S)? **[1.5]**

25/90= 0.278 Mbps

d. Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the client links (R_C)? **[1.5]**

25/40= 0.625 Mbps

Question 4 [15 Marks]



Consider that you are working on one of the lab systems of FAST-NUCES having a LAN network with 350 Mb/s transmission rate to institutional Router 1, 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 Lab's browsers to the origin servers is 40 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side (Router 2) of the access link forwards an HTTP request until it receives the response

is 1.5 seconds on average. Model the total average response time as the sum of the average access delay (that is, the delay from Router 2 to Router 1) and the average Internet delay.

a) Find the total average response time. **[8]**

L= 850, 000 Bits
R = 500 * 10^6 bits/ sec
a= 40
Cache response = 0.01 sec
Internet delay = 1.5 sec

Average Transmission Delay = T_{trans} = L / R = 0.85 * 10^6 / 500 * 10^6 = **0.0017 sec**

Traffic Intensity on the access Link = T_{trans} * a = (0.0017) * 40 = **0.068**

The average access delay is = T_{trans} / (1-Traffic intensity) = 0.0017 / (1- 0.068)

= 0.0018 sec

Final average response time = 0.0018 + 1.5 = **1.5018 sec**

b) Now suppose that a web cache is installed on the FAST Lab network's LAN. Suppose that the miss rate is 0.4. Find the total response time (considering that the **response time from the cache is 0.01 sec**) **[7]**

The average access delay is (**40 % for cache miss**)

Average Access delay = (0.0017sec) / [1 – **(0.4)** (0.068)] = **0.0017 seconds**
Average Response Time = 0.0017 sec + 1.5 sec =**1.5017 sec**

For Cache Hit (60 %)

The response time is approximately .01 sec if the request is satisfied by the cache

Average Access delay = 0.6 * 0.01 =**0.0006 sec**

Final Average Response Time = **(0.6)**(0.01) + **(0.4)** (1.5017) = 0.0006 + 0.6007 = **0.601 sec**

Thus, the average response time has been reduced from 1.5018 sec to 0.601 sec