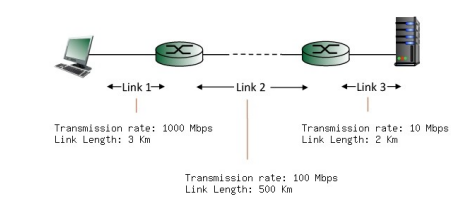
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| Course – Section | Computer Networks (CS3001 - Spring 2024) – (BCS-6A, BSE-6B, BSE-6C) |
| Assignment Num. | 01 |
| Total Marks | 50 |
| Start Date | 02-Febraury-2024 |
| Due Date/Time | 9-Febraury-2024 |
| Submission | Submit hard copy in class |

**Question 01 (5 marks)**

Consider the figure below, with three links, each with the specified transmission rate and link

length.



Find the end-to-end delay (including the transmission delays and propagation delays on each of the three links, but ignoring queueing delays and processing delays) from when the left host begins transmitting the first bit of a packet to the time when the last bit of that packet is received at the server at the right. The speed of light propagation delay on each link 2.5 \* 108 meters/sec. Note that the transmission rates are in Mbps and the link distances are in Km. Assume a packet length of 16000 bits. Give your answer in milliseconds.

Link 1 transmission delay = L/R = 16000 bits / 1000 Mbps = 0.016000 msec.

Link 1 propagation delay = d/s = 3 Km / 2.5 \*108 m/sec = 0.012 msec.

Link 2 transmission delay = L/R = 16000 bits / 100 Mbps = 0.160000 msec.

Link 2 propagation delay = d/s = 500 Km / 2.5\*108 m/sec = 2 msec.

Link 3 transmission delay = L/R = 16000 bits / 10 Mbps = 1.600000 msec.

Link 3 propagation delay = d/s = 2 Km / 2.5\*108 m/sec = 0.009 msec.

Thus, the total end-to-end delay is the sum of these six delays: 3.796 msecs.

**Question 02 (5 marks)**

Assume that you are downloading an MP3 file of 24 million bits (assume 1 million = 106 bits) from a server with one router between client host and server host. The transmission rate of the link from router to server i.e., Rs is 8 Mbps while transmission rate of your access link i.e., Rc is 6 Mbps. What will be the throughput? What is the required time to transfer the file considering that all delays except transmission delay are negligible?

Here, the only delay component is transmission delay.

Transmission rate of server = Rs = 8 Mbps = 8 \* 106 bps

Transmission rate of access link = Rc = 6 Mbps = 6 \* 106 bps

File size = L = 24 million bits = 24 \* 106 bits

Throughput is equal to the transmission rate of bottleneck link i.e., min {Rc , Rs} = Rc = 6 \* 106 bps

Having determined the throughput, delay i.e., time required to transfer the file = L/ min {Rc , Rs}

= L/ Rc = 24 \* 106/ 6 \* 106 = 4 sec

**Question 03 (5 marks)**

Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file. When one of these packets arrives to a router, what information in the packet does the router use to determine the link onto which the packet is forwarded? Why is packet switching on the Internet analogous to driving from one city to another and asking directions along the way?

End system A breaks the large file into chunks. It adds header to each chunk, thereby generating multiple packets from the file. The header in each packet includes the IP address of the destination (end system B). The packet switch uses the destination IP address in the packet to determine the outgoing link. Asking which road to take is analogous to a packet asking which outgoing link it should be forwarded on, given the packet’s destination address.

**Question 04 (5 marks)**

Consider a packet of length 1000 bytes, which starts at source end system and travels over 10 links to destination end system. Nine packet switches connect these ten links. The transmission rate of all ten links is 2 Mbps. Suppose that propagation speed on all 10 links is 2.5 \* 108 meters/sec. and each packet switch incurs a processing delay of 5 msec (assume zero processing delay at end systems). Moreover, suppose that the distance is the same i.e., 1000 km between all links (i.e., distance from source end system to packet switch 1, from packet switch 1 to packet switch 2, ..., and from packet switch 9 to destination end system is the same). Moreover, consider that no queuing delay exists, then what is the end-to-end delay for these values?

Length of packet = L = 1000 x 8 = 8000 bits

Transmission rate of links: R1=R2= R3= R4 = .... = R10 = 2 Mbps = 2 x 106 bps

So Transmission delay of each link (L/R): dtrans1 = dtrans2 = dtrans3 = .... = dtrans10 = 8000/ 2 x 106 = 4

msec

Propagation speed of links: s1 = s2 = s3 = ... = s10 = 2.5 x 106 m/s

Distance between links: d1 = d2 = d2= ... = d10=1000 km

For one link = dprop = d/s = 1000 x 103/ 2.5 x 108 = 4 msec

So propagation delay of one link = 5 msec

Processing delay of each packet switch: dproc1 = dproc2 = dproc3 = ... = dproc10 = 5 msec

dend-end = 10 \* dtrans + 10 \*dprop + 9 \* dproc = 10 x 4 + 10 \* 4 + 9 x 5 = 40 + 40 + 45 = 125 msec

**Question 05 (5 marks)**

Suppose you would like to urgently deliver 50 terabytes data from Boston to Los Angeles. You have available a 100 Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use FedEx overnight delivery? Explain.

50 terabytes = 50 \* 1012 \* 8 bits. So, if using the dedicated link, it will take 40 \* 1012 \* 8 / (100 \*106 ) =4000000 seconds = 46.29 days. But with FedEx overnight delivery, you can guarantee the data arrives in one night.

**Question 06 (5 marks)**

Suppose two hosts, A and B, are separated by 20,000 kilometers, and are connected by a direct link of R = 5 Mbps. Suppose the propagation speed over the link is 2.5 \* 108 meters/sec.

a. Calculate the bandwidth-delay product, R \* dprop.

b. Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?

c. Provide an interpretation of the bandwidth-delay product.

d. What is the width (in meters) of a bit in the link? Is it longer than a football field?

e. Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.

a) 400,000 bits

b) 400,000 bits

c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

d) the width of a bit = length of link / bandwidth-delay product, so 1 bit is 50 meters long, which is longer than a football field

e) s/R

**Question 07 (5 marks)**

Referring to question 6, suppose we can modify R. For what value of R is the width of a bit as long as the length of the link?

s/R=20000km, then R=s/20000km= 2.5\*108 /(2\*107 )= 12.5 bps

**Question 08 (5 marks)**

Consider question 6 but now with a link of R = 500 Mbps.

a. Calculate the bandwidth-delay product, R \* dprop.

b. Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one big message. What is the maximum number of bits that will be in the link at any given time?

c. What is the width (in meters) of a bit in the link?

a) 40,000,000 bits

b) 800,000 bits, this is because that the maximum number of bits that will be in the link at any given time = min(bandwidth delay product, packet size) = 800,000 bits.

c) .5 meter

**Question 09 (5 marks)**

Refer again to question 6.

a. How long does it take to send the file, assuming it is sent continuously?

b. Suppose now the file is broken up into 20 packets with each packet containing 40,000 bits. Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgment packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file?

c. Compare the results from (a) and (b)

a) ttrans + tprop = 160 msec + 80 msec = 240 msec.

b) 20 \* (ttrans + 2 tprop) = 20\*(8 msec + 160 msec) = 3.36 sec.

c) Breaking up a file takes longer to transmit because each data packet and its corresponding acknowledgement packet add their own propagation delays.

**Question 10 (5 marks)**

Consider a communication channel with a bandwidth of 1000 Mbps. If FDM is employed and each signal requires a bandwidth of 200 Mbps, how many signals can be accommodated simultaneously?

If TDM is used instead, and each signal is allocated a time slot of 10 milliseconds, how many signals can be accommodated within one second?

1000\*106 / 200 \*106 = 5

1/10\*10-3=100

(Good Luck)