Birzeit University
Faculty of Engineering and Technology
Department of Electrical and Computer Engineering
ENCS3320 – Computer Networks (Term 1241)

Name: SOLUTION **ID:** ________________ **Section:** ________

Note: You **must show** your **steps** in the area below every question. Not showing your **detailed** work for any question results in a score of zero.

Question 1 (2 points): State whether each of the following statements is true (**T**) or false (**F**):

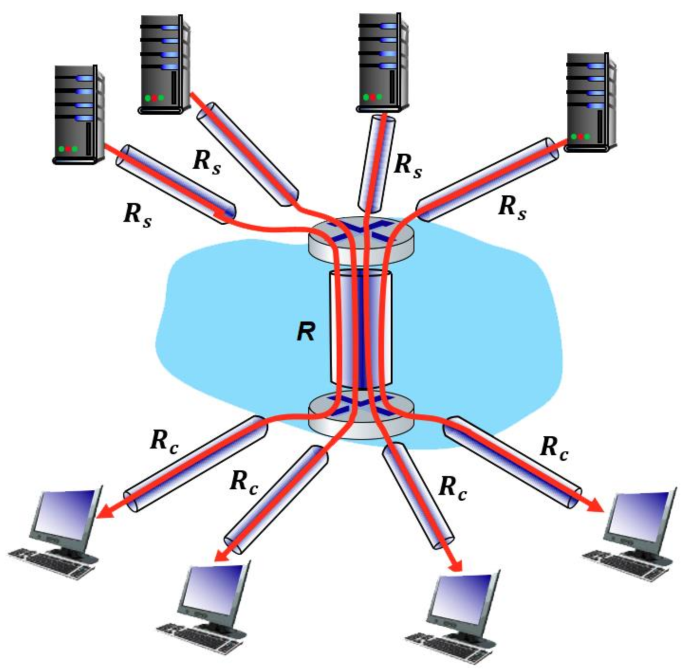
A) **F** The Internet exchange point (IXP) facilitates connections between Internet service providers (ISPs) and their respective clients.

B) **T** Frequency division multiplexing (FDM) allows for the simultaneous transmission of multiple signals by dividing the frequency spectrum, while time division multiplexing (TDM) allows for the sequential transmission of multiple signals by dividing time.

C) **F** Worm malware depends on user intervention (e.g., opening an infected file or running an infected program) to spread from one system to another.

D) **F** To successfully transfer user packets from one side of the network edge to the other, each device in the network core must implement all five layers of the protocol stack.

Question 2 (1.5 points): Consider the scenario shown on the right, 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 $R = 64$ Mbps. The four links from the servers to the shared link have a transmission capacity of $R_s = 13$ Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of $R_c = 12$ Mbps. Assuming that the servers are sending at the maximum rate possible, what is the link utilizations for the shared link (R)?



Per-connection end-end throughput = min(R_c, R_s, $R/4$)

= min(12, 13, 16) = 12 ➔ R_c is the bottleneck link

The link utilizations for the shared link (R) = $12/16$

$= 75\%$

<u>Question 3 (2 points):</u> Suppose that many users are sharing a 4.5 Mbps access link to the Internet. Suppose each user is either in active status and requires a data access rate of 500 Kbps, or in silent status and requires no data. Each user is active only 17% of the time and users are independent of each other in their activities.

A) If circuit switching is used, how many users can this access link support?

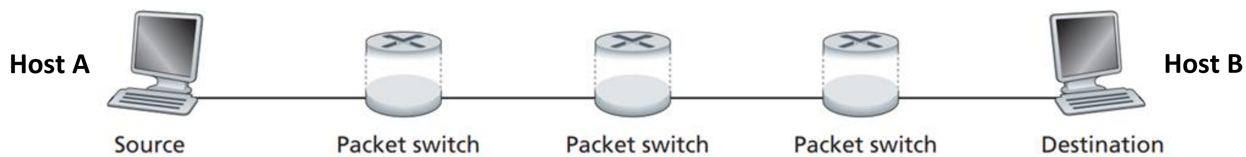
4.5 Mbps / 500 Kbps per user = 9 users

B) If packet switching is used with a total number of users, $N = 14$, what is the probability that this access link is idle, i.e., not carrying any traffic?

The link is idle ➔ The number of active users (X) is zero.

$$P[\mathrm{X} = 0] = \binom{14}{0}(0.17)^0(1-0.17)^{14-0} = (0.83)^{14} = 0.0736 = 7.36\%$$

<u>Question 4 (4.5 points):</u> Consider sending a file of 20 Mbits from Host A to Host B, there are three routers between A and B. The devices are separated by $\boldsymbol{R}$ bps links that are 625 km long each. Suppose that a packet-switched network is used, it segments the file into 10,000 packets with each packet having a 100-bit header. Assume that there are no queuing delays, the processing delay is negligible, and the speed of light is $2.5 \times 10^8\ m/s$. Calculate the minimum possible data rate, $\boldsymbol{R}$, of each link that is along the path such that the total time to deliver the file is less than or equal to 4.21126 seconds.



$$\text{File size } (F) = 20 \text{ Mbits, Header size } (H) = 100 \text{ bits, speed of light } (s) = 2.5 \times 10^8\ m/s, \text{ distance } (d) = 625 \text{ km, Number of links } (X) = 4, \text{ Number of packets } (N) = 10000$$

$$\text{Data per packet } (P_{\text{data}}) = \frac{F}{N} = \frac{20 \times 10^6}{10000} = 2000 \text{ bits}$$

$$\text{Packet size } (L) = P_{\text{data}} + H = 2000 + 100 = 2100 \text{ bits}$$

$$\text{Transmission delay } (d_{\text{trans}}) = \frac{L}{R} = \frac{2100}{R} \text{ seconds}$$

$$\text{Propagation delay } (d_{\text{prop}}) = \frac{d}{s} = \frac{625 \times 10^3}{2.5 \times 10^8} = 0.0025 \text{ seconds}$$

$$\text{Total delay} = 4.21126 \geq X \times (d_{\text{trans}} + d_{\text{prop}}) + (N-1) \times d_{\text{trans}}$$
$$\geq 4 \times (d_{\text{trans}} + 0.0025) + (10000 - 1) \times d_{\text{trans}}$$
$$\geq 10003 \times d_{\text{trans}} + 0.01$$

$4.21126 - 0.01 \geq 10003 \times d_{\text{trans}}$ ➔ $d_{\text{trans}} \leq \frac{4.20126}{10003} = 0.00042$ seconds

➔ $\frac{2100}{R} \leq 0.00042$ seconds ➔ $R \geq \frac{2100}{0.00042}$ ➔ $R \geq 5000000$ bps

➔ $R_{\text{min}} = 5$ Mbps

GOOD LUCK