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**):

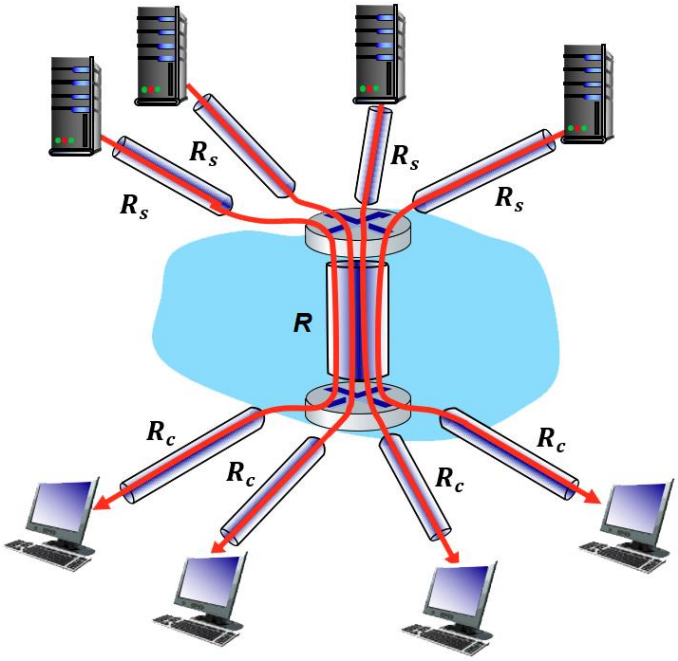
A) **T** In a digital subscriber line (DSL) access network, each home uses a dedicated line to transmit both voice and data to the central office simultaneously, utilizing separate frequency bands.

B) **T** In WiFi standards such as 802.11b and 802.11g, signals are transmitted bidirectionally, but only one direction at a time.

C) **F** Twisted-pair cables are more resistant to electromagnetic interference (EMI) than fiber-optic cables.

D) **T** In the layered Internet model, as a data packet moves from the lower to the upper layers, the header is removed.

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 $R = 80$ Mbps. The four links from the servers to the shared link have a transmission capacity of $R_s = 55$ Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of $R_c = 16$ 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 = $\min(R_c, R_s, R/4)$

= $\min(16, 55, 20) = 16$ ➔ R_c is the bottleneck link

The link utilizations for the shared link $(R) = 16/20$

$= 80\%$

Question 3 (2 points): Suppose that many users are sharing a 5.2 Mbps access link to the Internet. Suppose each user is either in active status and requires a data access rate of 400 Kbps, or in silent status and requires no data. Each user is active only 31% 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?

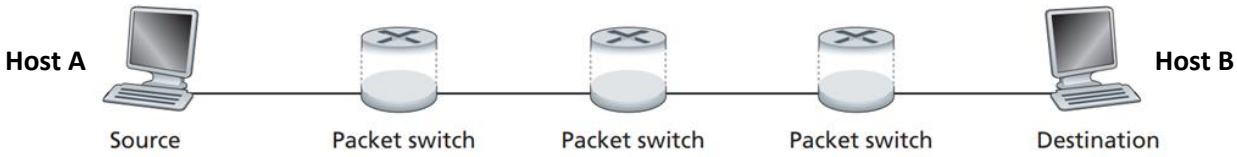
5.2 Mbps / 400 Kbps per user = 13 users

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.

$$P[\mathrm{X} = 0] = \binom{14}{0}(0.31)^0(1-0.31)^{14-0} = (0.69)^{14} = 0.0055 = 0.55\%$$

Question 4 (4.5 points): 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 ***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, ***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.



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

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

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

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

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

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

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

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

$$\rightarrow R_{\min} = 5 \text{ Mbps}$$

GOOD LUCK