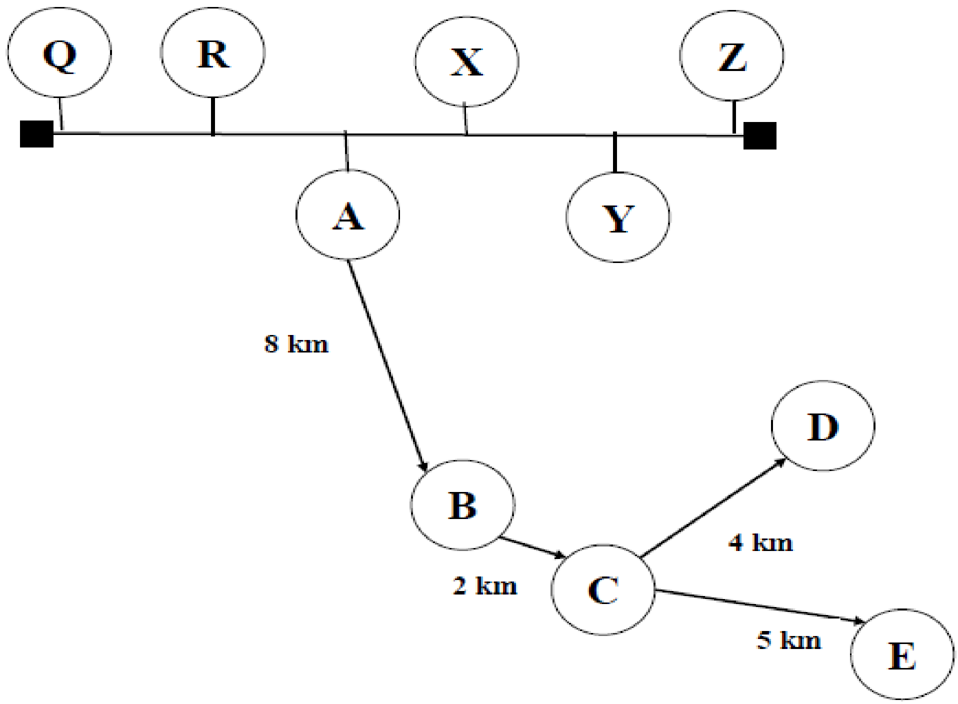
(17 pts) 16.



Given the internet pictured above with a propagation speed of **150 m/microsec**. on the **100BASE5** LAN and a propagation speed of **200 m/microsec.** on the store-forward packet-switched WAN where nodes **Q, R, A, X, Y** and **Z** are **equally spaced** on the Ethernet with nodes **Q** and **Z** at the opposite **maximum** possible extreme ends.

Nodes **A** to **E** are spaced on the WAN as shown with **2 Gbps** links between nodes. Assume it takes each WAN node **50 microsec.** to look up a packet's route in its routing table and that there is a **1 bit** delay for a Ethernet frame to pass through a node on the ether (excluding the sender and receiver nodes).

Assume an IP packet has **1300 bytes** and the frame header = **100 bytes** and the frame trailer = **100 bytes** on **both** the Ethernet LAN and the point-to-point WAN.

(17 pts.) 16a. How long will it take to send a frame from node **Z** to node **E** in the situation that when the frame arrives at node **C** there are **four** frames waiting to go to node **E** and **three** frames waiting to go to node **D**? Assume all frames are the same size and that there is no other traffic on the internet when the frame is sent.
{To receive full or partial credit, you MUST show all your work on the next page}

Frame size = 1300 + 100 + 100 bytes =1500 bytes X 8 = 12,000 bits 1.2×10^4 bits

Delay from Z to A D = PD +QD + TT +PT = 0 + 0 + TT + PT + 2 bits of delay

$$TT = \frac{1.2 \times 10^4 \text{ bits}}{10^8 \text{ Mbps}} = 1.2 \times 10^{-4} \text{ sec.} = 120 \text{ microsec.}$$

$$PT = \frac{300 \text{ meters}}{150 \text{ m/microsec}} = 2 \text{ microsec}$$

1 bit = $1/10^8$ sec = 10^{-8} sec = .01 microsec. x 2 = 0.02 microsec.
Delay from Z to A = 122.02 microsec

Blank Page

Delay from A to E (3 hops) D per hop = PD +QD + TT +PT = 50 microsec. + 0 + TT + PT (only queuing at C)

$$TT = \frac{1.2 \times 10^4 \text{ bits}}{2 \times 10^9 \text{ Mbps}} = 0.6 \times 10^{-5} \text{ sec.} = 6 \text{ microsec.}$$

QD = 4 x TT = 24 microsec

$$PT(AB) = \frac{8000 \text{ m}}{200 \text{ m/microsec}} = 40 \text{ microsec}$$

$$PT(BC) = \frac{2000 \text{ m}}{200 \text{ m/microsec}} = 10 \text{ microsec}$$

$$PT(CE) = \frac{5000 \text{ m}}{200 \text{ m/microsec}} = 25 \text{ microsec}$$

Delay from A to E = 3 hops x (PD +TT) + QD + PT(AB) + PT(BC) +PT(CE)
= 3 x (50 microsec + 6 microsec) + 24 microsec + (40 + 10 +25) microsec
= 168 microsec + 24 microsec + 75 microsec
= 267 microsec

Delay from Z to E = Delay from Y to A + Delay from A to E
= 122.02 microsec + 267 microsec
= 389.02 microsec