Answers to exercise #2 of Computer Networks

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Questions.

1. Consider sending a file of $M \times L$ bits over a path of Q links. Each link transmits at R bits per second. The network is lightly loaded so that there are no queuing delays. When a form of packet switching is used, the $M \times L$ bits are broken up into M packets, each packet with L bits. Propagation delay is negligible.

   (a) Suppose the network is a packet-switched virtual circuit network. Denote the VC set-up time by t_s seconds. Suppose the sending layers add a total of h bits of header to each packet. How long does it take to send the file from source to destination?

   (b) Suppose the network is a packet-switched datagram network and a connectionless service is used. Now suppose each packet has $2h$ bits of header. How long does it take to send the file?

   (c) Repeat case 1b but assume message switching is used (that is, $2h$ bits are added to the message, and the message is not segmented).

   (d) Finally, suppose that the network is a circuit-switched network. Further suppose that the transmission rate of the circuit between source and destination is R bit/s. Assuming t_s seconds of set-up and h bits of header appended to the entire file, how long does it take to send the file?

Answers.

1. The time to transmit one packet onto a link is $(L + h)/R$. The time to deliver the first of the M packets to the destination is $Q(L + h)/R$. Every $(L + h)/R$ seconds a new packet from the $M - 1$ remaining packets arrives at destination (this is due to pipelining). We must also add the initial setup time, because we use a VC network. Thus the total delay is

$$t_s + (Q + M - 1)\frac{L + h}{R}$$

2. Using a datagram network with a connectionless service implies there is no setup needed. Another difference with the previous situation is the header size. Therefore the total delay is simply

$$(Q+M-1)\frac{L+2h}{R}$$

3. The time to transmit the entire message over one link is $(ML+2h)/R$. The time to transmit the entire message over Q links (i.e. to destination) is thus

$$Q\frac{ML+2h}{R}$$

4. Because there is no store-and-forward delay at the switches, the total delay does not depend on the number of links. Also we must add the setup time. Therefore the end-to-end delay is

$$t_s+\frac{ML+h}{R}$$

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