Solutions for Assignment 1

7. Consider a point-to-point link 2km in length. At what bandwidth would propagation delay (at a speed of 2 x 108 m/s) equal transmit time for 100-byte packets? What about 512-byte packets?

Solution:
Since transmit = size/bandwidth and propagation = distance/speedofflight = 2*10^3 m / (2*10^8 m/s) = 1*10^{-5} s, we can conclude that bandwidth = size / (distance/speedofflight).
100 byte / 1*10^{-5} s = 10 MB/s = 80 Mbps
512 byte / 1*10^{-5} s = 409.6 Mbps

13. How “wide” is a bit on a 1-Gbps link? How long is a bit in copper wire, where the speed of propagation is 2.3*10^8 m/s?

Solution:
1Gbps = 10^9 bps, and 1 bit on a 1-Gbps link is 1 / 10^9 bps = 10^{-9} s wide.
If the speed of propagation is 2.3*10^8 m/s, then the length of a bit is (2.3*10^8 m/s) * (10^{-9} s) = 0.23m

15. Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is 385000 km and data travels over the link at the speed 3 x 10^8 m/s.
(a) Calculate the minimum RTT for the link.
(b) Using the RTT as the delay, calculate the delay*bandwidth product for the link.
(c) What is the significance of the delay*bandwidth product computed in (b).
(d) A camera on the lunar base takes pictures of Earth and saves them in digital format to disk. Suppose Mission Control on Earth wishes to download the most current image, which is 25MB. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?

Solution:
(a) RTT = 2*distance/speed = 2*3.85*10^8 m / (3*10^8 m/s) = 2.567s
(b) Delay*bandwidth = 2.567s*100Mbps = 256.7MB = 32.09 MB
(c) The delay*bandwidth product corresponds to how many bits the sender must transmit before the first bit arrives at the receiver.
(d) Total transfer time = RTT + transmit time = 2.567s + size/bandwidth = 2.567s + (25*8 / 100) s = 4.567s

18. Calculate the latency (from first bit sent to last bit received) for the following:
(a) A 10-Mbps Ethernet with a single store-and-forward switch in the path, and a packet size of 5000 bits. Assume that each link introduces a propagation delay of 10 μs, and that the switch begins retransmitting immediately after it has finished receiving the packet.
(b) Same as (a) but with 3 switches.
(c) Same as (a) but assume the switch implements “cut-through” switching: it is able to begin retransmitting the packet after the first 200 bits have been received.

Solution:
(a) Each line has a transmit delay = size / bandwidth = 5000 bits / 10 Mbps = 5*10^-4 s. There are 2 links, each produces 2*10*10^-6 s = 2*10^-5 s. So the latency is 2*transmit delay + propagation delay = 1.02*10^-3 s.
(b) 3 switches have 4 lines. The latency is 4*transmit delay + 4*propagation delay = 2.04*10^-3 s.
(c) With “cut-through” switching, the transmit delay of the first line is 200 bits / 10 Mbps = 2*10^-5 s. So the latency = 2*propagation delay + first transmit delay + second transmit delay = 2*10^-5 s + 2*10^-5 s + 5*10^-4 s = 5.4*10^-4 s.

24. Suppose that a certain communications protocol involves a per-packet overhead of 100 bytes for headers and framing. We send 1 million bytes of data using this protocol; however, one data type is corrupted and the entire packet containing it is thus lost. Give the total number of overhead + loss bytes for packet data sizes of 1000, 5000, 10000, and 20000 bytes. Which size is optimal?

Solution:
Packet number = 1*10^6 / Data Size.
Total overhead = 100 bytes * Packet number = 100*(1*10^6 / Data Size)
Lose = data size
Total size = total overhead + lose = 100*(1*10^6 / Data Size) + data size

1000 bytes: 1*10^8 / 1000 + 1000 = 1.01*10^5
5000 bytes: 1*10^8 / 5000 + 5000 = 2.5*10^4
10000 bytes: 1*10^8 / 10000 + 10000 = 2*10^4
20000 bytes: 1*10^8 / 20000 + 20000 = 2.5*10^4
The 10000 bytes is optimal.