Chapter 1 - Part 2

Foundation

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February, 2014
Exercise 3

Calculate the total time required to transfer a 1000-KB file in the following cases, assuming an RTT of 50 ms, a packet size of 1 KB data, and an initial $2 \times$ RTT of “handshaking” before data is sent:

(a) The bandwidth is 1.5 Mbps, and data packets can be sent continuously.

Here, we send all packets as soon as they are ready. After calculating the total packets, we use the formula for transmission time and propagation time. The total transfer time is then calculated as the sum of connection time, transmission time of packets, and propagation time.

$\# packets = \frac{\text{File Size}}{\text{packet size}} = \frac{1000}{1} = 1000 \text{ Packet.}$

Transmission time $(tr) = \frac{\text{packet size}}{\text{data Rate}}$

$= \frac{1 \text{ KB}}{1.5 \text{ Mbps}} = \frac{1 \times 8 \times 10^3}{1.5 \times 10^6}$

$= 5.333 \text{ ms.}$

Propagation time $(tp) = \frac{\text{distance}}{\text{velocity}} = 0.5 \times \text{RTT} = 25 \text{ ms.}$

Transfer Time = connection time + $\# pack \times tr + tp$

$= 2 \times 50 + 1000 \times 5.333 + 25 = 5458 \text{ ms} = 5.458 \text{ sec.}$

(b) The bandwidth is 1.5 Mbps, but after we finish sending each data packet we must wait one RTT before sending the next.

Here, we send all packets as soon as they are ready. After calculating the total packets, we use the formula for transmission time and propagation time. The total transfer time is then calculated as the sum of connection time, transmission time of packets, and propagation time.

$\# packets = \frac{\text{File Size}}{\text{packet size}} = \frac{1000}{1} = 1000 \text{ Packet.}$

Transmission time $(tr) = \frac{\text{packet size}}{\text{data Rate}}$

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Propagation time $(tp) = \frac{\text{distance}}{\text{velocity}} = 0.5 \times \text{RTT} = 25 \text{ ms.}$

Transfer Time = connection time + $\# pack \times tr + tp$

$= 2 \times 50 + 1000 \times 5.333 + (999 \times 25) + 25 = 55408 \text{ ms} = 55.408 \text{ sec.}$
(c) The bandwidth is “infinite,” meaning that we take transmit time to be zero, and up to 20 packets can be sent per RTT.

This means that the bandwidth is infinite, and during the first RTT we can send one packet (2-1), during the second RTT we can send two packets (22-1), during the third we can send four (23-1), and so on. (A justification for such an exponential increase will be given in Chapter 6.)

(d) The bandwidth is infinite, and during the first RTT we can send one packet (2-1), during the second RTT we can send two packets (22-1), during the third we can send four (23-1), and so on. (A justification for such an exponential increase will be given in Chapter 6.)
Exercise 5

Consider a point-to-point link 4 km in length. At what bandwidth would propagation delay (at a speed of 2×10^8 m/s) equal transmit delay for 100-byte packets? What about 512-byte packets?

For 100 byte:
D= 4 Km.
R=??
V= 2*10^8 m/s.
Packet size= 100B = 100*8=800 bit.

Tp = tr
D/V = PacketSize/R
4*10^3/ 2*10^8 = 800/R
R = 40000000 bps = 40 Mbps.

For 512 byte:
R = 204800000 bps= 204.8 Mbps

Exercise 13

Suppose a 1-Gbps point-to-point link is being set up between the Earth and a new lunar colony. The distance from the moon to the Earth is approximately 385,000 km, and data travels over the link at the speed of light—3×10^8 m/s.

(a) Calculate the minimum RTT for the link.

R= 1*10^9 bps.
D= 385000* 10^3 m.
V= 3*10^8 m/s.
Rtt = 2* tp = 2 * (D/ V) = 2 * (385000* 10^3/3*10^8) = 2.5667 sec.

(b) Using the RTT as the delay, calculate the delay × bandwidth product for the link.
Delay × Bandwidth = Rtt × R = 2.5667 × 10^9 = 2.5667 Gb.

(c) What is the significance of the delay × bandwidth product computed in (b)?

This represents the amount of data the sender can send before it would be possible to receive a response.

(d) A camera on the lunar base takes pictures of the Earth and saves them in digital format to disk. Suppose Mission Control on Earth wishes to download the most current image, which is 25 MB. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?

Data size = 25 MB = 25 × 8 × 10^6 bit = 2 × 10^8 bit.
Transfer time = Connection time + tr + tp
= 2.5667 + (2 × 10^8)/10^9 + 0.5 × 2.5667 = 4.05005 sec.

Exercise 16

Calculate the latency (from first bit sent to last bit received) for the following:

(a) 100-Mbps Ethernet with a single store-and-forward switch in the path and a packet size of 12,000 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.

R = 100 Mbps
Packet size = 12,000 bit.
Tp = 10 × 10^-6 sec.

Latency = 2 × tr + 2 × tp = 2 × (12,000/100 × 10^6) + 2 × 10^-6 = 0.00026 sec.
(b) Same as (a) but with three switches.

Latency = 4*(tr+tp) = 0.00052 sec.

(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.

Latency = tr + 2*tp = 0.00012 + 2*10*10^-6 = 0.00014 sec = 140 us.

Exercise 20

Hosts A and B are each connected to a switch S via 100-Mbps links as in Figure 1.21. The propagation delay on each link is 20 μs. S is a store-and-forward device; it begins retransmitting a received packet 35 μs after it has finished receiving it. Calculate the total time required to transmit 10,000 bits from A to B.

(a) As a single packet.

Latency = 2*tr + 2*tp + 35us
= 2*(10000/100Mbps) + 2*20 + 35 = 275 us.
(b) As two 5000-bit packets sent one right after the other.

In the beginning, the first packet is sent through the link, and after its completion, the second packet is sent. Both packets are stored and forwarded. 

\[
\text{Latency} = \text{Latency for the first packet} + (n-1)*tr
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