cs375: Computer Networks

Homework 3: Performance

Total Points: xx

1. (P&D 1.5, a,b,c; 6 pts) We will count as completed when the last data bit arrives at its destination. An alternative interpretation would be to count until the last ACK arrives back at the sender, in which case the time would be half an RTT (50ms) longer.

    (a) 2 initial RTTs (200ms) + 1000KB/1.5Mbps (transmit) + RTT/2 (prop) So we get 8192000 bits / 15000000 bits per sec for 5.46 sec transmit + .2 (handshake) + .05 (prop) = 5.71 sec. (5.76 for alternate interpretation).

    (b) To the above, we add the time for 999 RTTs (in between each data transfer from first scenario) for 5.71 + 99.9 = 105.61 sec. (or 105.66 for alternate interp.)

    (c) This is initial 2 RTT handshake plus 49.5 RTTs for transfer. Add .5 RTT for final ack so sender knows we are complete for the alternate interp. So 5.15 sec (5.2 sec for alternate interp.)

2. (P&D 1.15; 7 pts)

    (a) The minimum RTT is $2 \times 385,000,000m/(3 \times 10^8 m/\text{sec.}) = 2.57$ sec.

    (b) The delay-bandwidth product is 2.57 sec. $\times$ 100 Mbps = 257 Mb = 32 MB.

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

    (d) We require at least one RTT before the picture could begin arriving at the ground (TCP would take two RTTs). Assuming bandwidth delay only, it would take 25MB/100Mbps = 200Mb/100Mbps = 2 sec. to finish sending, for a total time of 2.0 + 2.57 = 4.57 sec. until the last picture bit arrives on earth.

3. (P&D 1.18; 6 pts)

    (a) One packet consists of 5000 bits, and is so delayed due to bandwidth 500 μsec along each link (transmit). The packet is also delayed 10 μsec in propagation on each link. Total delay is 1020 μsec.

    (b) With three switches and four links, the delay is

    $$4 \times 500\mu\text{s} + 4 \times 10\mu\text{s} = 2.04\text{ms}$$

    (c) With cut-through, the switch delays the packet by 200 bits = 20 μs. There is still one 500 μs delay waiting for the last bit, and 20 μs of propagation delay, so the total is 540 μs. (This is the answer to the question *as asked*, extending from part (a). If you answered relative to the part (b) scenario, where there are 3 intermediate switches, that extended answer follows.) With three cut-through switches, the total delay would be:

    $$500 + 3 \times 20 + 4 \times 10 = 600\mu\text{s}$$

4. (P&D 1.20; 6 pts)

   (a) The effective bandwidth is 10Mbps; the sender can send data steadily at this rate and the switches simply stream it along the pipeline. We are assuming here no ACKs are sent, and that the switches can keep up and can buffer at least one packet. Even if we assume ACKs, as long as we have sufficient space in the receiver window to have up to the (round-trip) delay-bandwidth product unacknowledged, then we can obtain the 10Mbps effective bandwidth. Most of you answered this assuming a stop-and-wait ack scheme, which is really what is being asked in part (b).

   (b) The data packet takes 2.04 ms as in 18(b) above to be delivered; the 400 bit ACKs take 40 μs transmit and 10 μs prop for each link for a total of 200 μs on the return, for 2.04 + 0.2 = 2.24 ms total RTT. 5000 bits in 2.24 ms is about 2.2 Mbps, or 280 KB/s.

   (c) $100 \times 6.5 \times 10^8$ bytes 12 hours $= 6.5 \times 10^{10}$ bytes $/(12 \times 3600\text{s}) \approx 1.5$ MB/s $= 12$Mbps.

5. (P&D 1.21; 8 pts)

   (a) $1 \times 10^7 b/s \times 10^{-6} s = 100$ bits = 12.5 bytes.

   (b) The first-bit delay is 520 μs through the store-and-forward switch, as in 18(a). $10^7 b/s \times 520 \times 10^{-6} s = 5200$ bits Alternatively, each link can hold 100 bits and the switch can hold 5000 bits.

   (c) $1.5 \times 10^6 b/s \times 50 \times 10^{-3} s = 75000$ bits = 9375 bytes.

   (d) This was intended to be *through* a satellite, originating at the ground and destination at the ground, since just going one-way to a satellite doesn't make much sense. This ground-to-ground interpretation makes the total one-way travel distance 2×359000000 meters. With a propagation speed of $c = 3 \times 10^8$ m/s, the one-way propagation delay is thus $2 \times 35900000/c = 0.24$ sec. Delay-bandwidth is thus 1.5×10^6b/s $\times\ 0.24$s $=$ 360000bits ≈ 45 KB.

6. (P&D 1.23; 4 pts)

   (a) Without any compression, the total transfer time is the size of the file divided by the bandwidth (b), or 1 MB / b in this case. When we compress, the total time is the sum of the compression time and the transfer time, or *compression_time* + *compressed_size/b*. Finding the bandwidth point at which the two are equal tells us (relative to bandwidth) when it is worth taking extra time for compression because the reduction in transfer time gives us an overall "win."

   Equating the two scenarios and solving for b, we get:

$$
\begin{aligned}
1\text{s} + \frac{0.5 \times 8 \times 2^2 0\text{bits}}{b} &= 2\text{s} + \frac{0.4 \times 8 \times 2^2 0\text{bits}}{b} \\
b &= \frac{(0.5 \times 8 \times 2^2 0\text{bits}) - (0.4 \times 8 \times 2^2 0\text{bits})}{1\text{s}} \\
b &= \frac{0.1 \times 8 \times 2^2 0\text{bits}}{1\text{s}} \\
b &= 838860.8\text{bps}
\end{aligned}
$$

(b) Latency does not affect the answer because it would affect the compressed and uncompressed transmission equally.

7. (P&D 1.28 a-c; 6 pts)

   (a) $640 \times 480 \times 3 \times 30$ bytes/sec = 27648000 bytes/s = 221184000 bps = 221.2 Mbps

   (b) $160 \times 120 \times 1 \times 5$ bytes/sec = 96000 bytes/s = 768000 bps = 768Kbps

   (c)

$$\begin{aligned}\frac{650\text{MB}}{75\text{min}} &= \frac{650 \times 10^6\text{bytes}}{75 \times 60\text{sec}} \\ &= 144444.4\text{bytes/s} \\ &= 1155555.2\text{bps} \\ &= 1.16\text{Mbps}\end{aligned}$$

   (d) Alternate interpretation of MB on CD-ROM:

$$\begin{aligned}\frac{650\text{MB}}{75\text{min}} &= \frac{650 \times 2^{20}\text{bytes}}{75 \times 60\text{sec}} \\ &= 151461\text{bytes/s} \\ &= 1211688\text{bps} \\ &= 1.21\text{Mbps}\end{aligned}$$