Solutions to Homework#0

5. We will count the transfer 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 (50 ms) longer.

   (a) 2 initial RTT's (200ms) + 1000KB/1.5Mbps (transmit) + RTT/2 (propagation) ≈ 0.25 + 8Mbit/1.5Mbps $= 0.25 + 5.33$ sec $= 5.58$ sec. If we pay more careful attention to when a mega is 10^6 versus 2^{20}, we get 8,192,000 bits/1,500,000 bits/sec $= 5.46$ sec, for a total delay of 5.71 sec.

   (b) To the above we add the time for 999 RTTs (the number of RTTs between when packet 1 arrives and packet 1000 arrives), for a total of $5.71 + 99.9 = 105.61$.

   (c) This is 49.5 RTTs, plus the initial 2, for 5.15 seconds.

   (d) Right after the handshaking is done we send one packet. One RTT after the handshaking we send two packets. At n RTTs past the initial handshaking we have sent $1 + 2 + 4 + \cdots + 2^n = 2^{n+1} - 1$ packets. At $n = 9$ we have thus been able to send all 1,000 packets; the last batch arrives 0.5 RTT later. Total time is 2+9.5 RTTs, or 1.15 sec.

NOTE: 1) differentiate different factors of delay. RTT mainly accounts for "propagation and queuing delay" here. 2) For questions (c) and (d), we only need RTT/2 time (instead of a full RTT time) for the last transmission.

7. Propagation delay is 2×10^3 m/(2×10^8 m/sec) $= 1 \times 10^{-5}$ sec $= 10\,\mu$s. 100 bytes/10 μs is 10 bytes/μs, or 10 MB/sec, or 80 Mbit/sec. For 512-byte packets, this rises to 409.6 Mbit/sec.

12. STDM and FDM both work best for channels with constant and uniform bandwidth requirements. For both mechanisms bandwidth that goes unused by one channel is simply wasted, not available to other channels. Computer communications are bursty and have long idle periods; such usage patterns would magnify this waste.

    FDM and STDM also require that channels be allocated (and, for FDM, be assigned bandwidth) well in advance. Again, the connection requirements for computing tend to be too dynamic for this; at the very least, this would pretty much preclude using one channel per connection.

    FDM was preferred historically for tv/radio because it is very simple to build receivers; it also supports different channel sizes. STDM was preferred for voice because it makes somewhat more efficient use of the underlying bandwidth of the medium, and because channels with different capacities was not originally an issue.

15. (a) The minimum RTT is $2 \times 385,000,000\,\text{m} / 3\times10^8\,\text{m/sec} = 2.57$ sec.

(b) The delay$\times$bandwidth product is 2.57 sec$\times$100 Mb/sec = 257Mb = 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 then take 25MB/100Mbps = 200Mb/100Mbps = 2.0 sec to finish sending, for a total time of $2.0 + 2.57 = 4.57$ sec until the last picture bit arrives on earth.

28. (a) $640 \times 480 \times 3 \times 30$ bytes/sec = 26.4 MB/sec

(b) $160 \times 120 \times 1 \times 5$ = 96,000 bytes/sec = 94KB/sec

(c) 650MB/75 min = 8.7 MB/min = 148 KB/sec

(d) $8 \times 10 \times 72 \times 72$ pixels = 414,720 bits = 51,840 bytes. At 14,400 bits/sec, this would take 28.8 seconds (ignoring overhead for framing and acknowledgements).

NOTE: 72 * 72 pixels per squre-inch