Course ISE 327, EEE 051: Introduction to Computer Networks
Recitation 1 Exercise

Michael J. May

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1 Question 1

Calculate the total time required to transfer a 1.5-MB file in the following cases, assuming an RTT of 80 ms, a packet size of 1 KB and an initial $2 \times$ RTT of handshaking before data is sent.

(a) The bandwidth is 10 Mbps, and data packets can be sent continuously.

(b) The bandwidth is 10 Mbps, but after we finish sending each data packet we must wait one RTT before sending the next.

(c) The bandwidth is "infinite", meaning that we take transmit time to be zero, and up to 20 packets can be sent per RTT.

(d) The bandwidth is infinite, and during the first RTT we can send one packet (2^{1-1}), during the second we can send two packets (2^{2-1}), during the third we can send four (2^{3-1}), and so on. (A justification for such an exponential increase will be given in Chapter 6)

1.1 Answer

We will count the transfer as completed when the last data bit arrives at its destination.

(a) 1.5MB = 12,582,912 bits. 2 initial RTTs (160 ms) + 12,582,912/10,000,000 bps (transmit) + RTT/2 (propagation) $\approx$ 1.458 seconds.

(b) To the above we add the time for 1535 RTTs (the number of RTTs between when packet 1 arrives and packet 1536 arrives), for a total of 1.458 + 122.8 = 124.258

(c) This is $ceil(76.8) = 77$ RTTs, plus the initial 2 for 6.32 seconds.

(d) Right after 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 $1 + 2 + 4 + \ldots + 2^n = 2^{n+1} - 1$ packets. At $n = 10 = 2047$ we have thus been able to send all 1536 packets

2 Question 2

Calculate the total time required to transfer a 1000-KB file in the following cases, assuming an RTT of 100 ms, a packet size of 1 KB and an initial 2× RTT of "handshaking" before data is sent.

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

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

(c) The bandwidth is "infinite," meaning that we take transmit time to be zero, and up to 20 packets can be sent per RTT.

(d) The bandwidth is infinite, and during the first RTT we can send one packet (2^{1-1}), during the second RTT we can send two packets (2^{2-1}), during the third we can send four (2^{3-1}), and so on.

2.1 Answer

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 (50ms) longer.

(a) 2 initial RTT's (200ms) + 1000KB/1.5Mbps (transmit) + RTT/2 (propagation)

$$\approx 0.25 + 8\text{Mbit}/1.5\text{Mbps}$$

$$= 0.25 + 5.33\text{sec}$$

$$= 5.58\text{sec}$$

If we pay more careful attention to when a mega is 10^6 versus 2^{20}, we get

$$8,192,000\text{bits}/1,500,000\text{bits/sec}$$

$$= 5.46\text{sec}$$

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 (we don't need to count the last half RTT), 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 $1 + 2 + 4 + \ldots + 2^n = 2^{n+1} - 1$ 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.