CSE 123: Computer Networks
Homework 1 Solutions

2. Transmission Time

a. Calculate the total time required (measured from the start of transmission at the sender to completion of reception at the receiver) to transfer a 4-MB file over a 5-Mbps link assuming an RTT of 200 ms and an initial 2 x RTT "handshake" using a packet size of 2 KB. You may assume packets can be sent continuously after completion of the handshake (i.e., there is no flow-control delay).

The packet size is immaterial because the packets are sent continuously.

$t_{total} = t_{handshake} + t_{transmit} + t_{propogation}$
$t_{handshake} = 2 \times RTT = 400ms$
$t_{propogation} = RTT/2 = 100ms$
$t_{transmit} = (4 \times 8 \times 1024 \times 1024) / (5{,}000{,}000) = 6.711s$
$t_{total} = 7.211s$

b. Now, let us generalize this and find the total time required to transfer a file of 's' MB assuming an RTT of 'r' ms, an initial 'k' x RTT of "handshaking", a bandwidth of 'B' Mbps and packet size of 'p' KB.

The packet size is immaterial because the packets are sent continuously.

$t_{total} = t_{handshake} + t_{transmit} + t_{propogation}$
$t_{handshake} = k \times RTT = (k \times r)\ ms$
$t_{propogation} = RTT/2 = (r/2)\ ms$
$t_{transmit} = (s \times 8 \times 1024 \times 1024) / (B \times 1{,}000{,}000) =$
$t_{total} = kr/1000 + r/2000 + (s/B)x(8.389)$ seconds

c. Verify that your generalization gives you the right answer when substituted with values from (a). That is, show that by plugging in the values from (a) into the equation you derive for (b), you obtain the answer you provided for part (a).

$t_{total} = kr/1000 + r/2000 + (s/B)x(8.389)$ seconds
$t_{total} = 2x200/1000 + 200/2000 + (4/5)x(8.389)$ seconds
$= 0.4 + 0.1 + 6.711 = 7.211s$

3. Analyzing the Dial-Up Modem

The speeds of the erstwhile dial-up modem are stuff of legends. Let us analyze the efficiency of the dial-up modem. A dial-up modem transmits digital data over a voice-grade analog phone line which passes a frequency range of 300 Hz to 3300 Hz.

a. What is the bandwidth of the analog phone line? What is the minimum SNR required on the line for the dial-up modem to achieve its stated rate of 56 kbps?

Bandwidth = |f2 - f1| = 3000Hz
56×10^3 = 3000.lg(1 + S/N)
SNR = 10xlog(S/N) = 56.2 dB

b. If the analog phone-line channel SNR were 25 dB, then what would be the maximum possible speed at which a dial-up modem could communicate?
SNR = 10xlog(S/N)
S/N = 316.22
C = 3000 x lg(317.22) = 25 kbps approx

4. MAVEN Spacecraft

NASA recently launched a space probe, called MAVEN, designed to study the Martian atmosphere while orbiting Mars. MAVEN uses an X-Band (i.e., RF) communication system to achieve a 550 kbps point to point link between it and the Earth station. The distance between Earth and Mars is approximately 55 million km.

a. Calculate the minimum RTT and the bandwidth-delay product for the link
Delay = Distance/Speed = $(55 \times 10^9)/(3 \times 10^8)$ = 184
RTT = 2 x Delay = 368 seconds
Bandwidth Delay product is
$184 \times 550 \times 10^3$ = 101,200,000 bits = 12.06 MB
NOTE: RTT x Bandwidth is also a correct answer.

b. Let us assume that the space probe sends 10 MB of data back to earth periodically. What would be the total time take for Earth station to get the entire 10MB data? (ie. the time taken for a single 10MB data transfer)
10MB = 83,886,080 bits
Transmit delay = size/speed = 10MB/550×10^3 = 152.52s
Propagation delay = 184s
Total time = 336.52s

Assume the speed of light through outer space is 3×10^8 m/s

5. Network Architecture

a. What are the 4 layers in the Internet model of the network architecture?
The 4 layers in the Internet model are
   a. Data Link Layer
   b. Network Layer
   c. Transport Layer
   d. Application Layer

b. Give two benefits of a layered architecture.
Two possible benefits of a layered architecture could be
   a. Modularity
   b. Well defined interfaces allowing for better protocol and system designs

6. Encoding and Issues with Encoding

Bit Sequence: 1 1 0 1 0 0 0 0 0 1 0 1 1 1 1 1

a. Encode the above bit sequence using the NRZ encoding scheme. The above bit sequence is indicative of the issues that the NRZ encoding scheme might face. What are they?

In NRZ a long string of 0s and 1s as above, leads to two fundamental issues

1. *Baseline wander*
2. *Clock recovery*

b. Encode the bit sequence using the NRZI encoding scheme. How is this encoding scheme better than the NRZ scheme?

In NRZI we make a transition from the current signal to encode a 1 and stay at the current signal to encode 0. NRZI thus solves the issue of baseline wander and clock recovery for a long string of 1s but not for a long strings of 0s.

c. Encode the bit sequence using the Manchester scheme. How does this encoding improve upon both the NRZ and NRZI scheme? Are there any remaining issues with this encoding scheme?

In Manchester fixes the issues with long string of both 0s and 1s as the encoding includes a transition in the signal for both 0 and 1. However, as a result of this the rate at which signal transitions is doubled. Manchester encoding is only 50% efficient.

d. In what way is the 4B/5B encoding scheme better than Manchester encoding scheme, if at all?

The 4B/5B encoding scheme tackles the main problem in the Manchester encoding, namely that of inefficiency, by encoding extra bits to prevent long strings of 0s and 1s to be transmitted.

See Chapter 2, Section 2.2 Encoding

7. 2B/5B Encoding Scheme

Similar to a 4B/5B encoding scheme let us concoct a new encoding 2B/5B that is every 2 bits of actual data will have a 5 bit code associated with it.

2B	**5B**
00	00000
01	10101
10	11010
11	01111

a. How many errors can be detected using the above set of codewords?
b. How many errors can be corrected if any?
   Hamming Distance = 3
   We can detect 2d errors and correct d errors if the Hamming distance is 2d + 1. Thus, we can detect 2 bit errors. and correct 1 bit errors.
c. Is this an efficient encoding? Why or why not?
   No. For an encoding to be efficient all they codewords need to be equidistant.
d. What is the efficiency of this 2B/5B encoding scheme?
   Efficiency is ⅖ = 0.40 ie. 40%

8. HDLC Framing

The following bit sequence arrives over the link

0111 1110 1000 0111 1101 1001 1110 1000 0111 1101 1110 1111 1111 0111 1110

Frame Start Stuffed Bit Stuffed Bit Error Frame End

If the HDLC protocol was used for framing, mark the following
a. Start of frame
b. End of frame
c. Stuffed bits
d. Bits indicating errors