CSE 123: Computer Networks

Homework 1 Solutions
Out: 09/30, Due: 10/07

Pluto with a heart

NASA's New Horizon, flying past Pluto, captured the iconic picture of Pluto's "Icy heart" which is of size 12MB. The bandwidth of the transmission link used is 1Kbps. The distance between Houston and New Horizon at that time is approximately 7.5 billion kilometers. Assume the speed of light in vacuum to be 3 x 10^8 m/s.

a) What is the total time elapsed between the start of transmission by New Horizon and the complete reception of the image at Houston?

Time taken = Propagation delay + transmission time
= (7.5*10^12)/(3*10^8) + 12*1024*1024*8/1000
= 25000 + 100663.3 s
= 34.9 hours

b) If the transmission of the data from New Horizon commences immediately after a start instruction, sent from Houston, is received at New Horizon. The start instruction is sent from Houston via a packet of size 2KB. What is the total time elapsed between Houston sending the start instruction and the complete reception of the image?

Time taken = Time taken to send 2KB from Houston + Time in part(a)
= (25000 + 2*1024*8/1000)/3600 + 34.9 hours
= 41.84 hours

c) Now let us assume New Horizon has clicked hundreds of pictures of Pluto and is ready to transmit data back to back non-stop. How many bits of data would it transmit before Huston gets the first bit?

Bandwidth delay product = 1000 * 25000 bits
= 2.5 * 10^7 bits

Cable modem

A cable modem transmits using 3KHz bandwidth channels. The receptor attached to the modem receives signal with a variable signal to noise ratio (SNR) which is atleast 25dB during the day and atleast 35dB during the night owing to the noisy days.

a) What is the maximum achievable channel capacity for the setup during the day and the night?

During day:
SNR = 10log(S/N) ***(log to the base 10)***
S/N = 316.23

C = 3000*log(1+316.23) ***(log to the base 2)***
= 24.93 Kbps

During night:
S/N = 3162.3
C = 3000*log(1+3162.3) ***(log to the base 2)***
= 34.88 Kbps

b) Shannon's Law states that C is proportional to B for a constant S/N ratio. Why should the channel capacity increase if we increase the channel bandwidth (B)? Give a qualitative argument. Note that channel bandwidth represents the frequency range at which the channel is being operated.
Because as the maximum frequency of the bandwidth-limited channel increases, more symbols can be packed in a fixed time period without aliasing (ie, without the two symbols interfering with each other and causing distortion) – corollary of Nyquist theorem.

Ideal receiver

Suppose you are designing a receiver which should be able to read all the symbols (bits) being transmitted (that is, not lose any information). The receiver is to be connected to a channel which can allow a maximum frequency f.
What should be your minimum sampling rate of the incoming data to ensure no loss of information? Give a brief justification.
Needs to be atleast 2f since according to Nyquist theorem 2f symbols can be packed in a unit time-period for a bandwidth-limited channel of frequency f. In other words, to read all the 2f symbols one needs to read (sample) 2f times in a given period to get all of them.

Encoding

a) Using the 4B/5B encoding map table present at Table 2.2 of Peterson and Davie(5^{th} edition), show the 4B/5B encoding and the resultant NRZI encoding for the following bit sequence:
1110 1101 1011 0000 1111 1010

New encoding (5 bits clubbed together for easy visualization) :
11100 11011 10111 11110 11101 10110
Draw NRZI of this sequence.
b) Encode the given bit sequcence in part (a) using the Manchester encoding.
Draw Manchester encoding of the original sequence.
c) Which among the two 4B/5B and Manchester encoding is better? Give a brief reason.
4B/5B is better since it achieves 80% (4/5) efficiency unlike Manchester which achieves 50% (2 bits sent for every bit).

Byte Stuffing

BISYNC is a sentinel based framing approach wherein the payload (data portion) of the frame is present between two sentinel characters STX (start-of-text) and ETX (end-of-text). The stuffing is done with an escape character DLE (data-link-escape). Following frame (excluding SYNs) message is received on the wire:
0x4e 0xad 0x32 0x23 0x4e 0x23 0x23 0xbc 0xda 0x23 0xfc 0x14 0xef 0xfc

Assuming that the above frame has no errors, answer the following-
a) Write down the STX, ETX and DLE bytes in this case.
STX = 0x4e
ETX = 0xfc
DLE = 0x23
b) What is the actual payload sent (unstuffed payload)? Remember payload consists of only the characters between the STX and ETX.
0xad 0x32 0x4e 0x23 0xbc 0xda 0xfc 0x14 0xef (removing stuffed DLE from payload)