CSE123 Spring 2015 Homework #1
Instructor: Stefan Savage

Due Wednesday 4/15 **at the beginning of class**

1. Mars Rover

The Mars rover must communicate to Earth over a point to point link with a bandwidth of 128-Kbps. Assume, the distance from Earth to Mars (when they are closest together) is approximately 55 Billion meters and data travelers over the link at the speed of light (3x10^8 m/s).

a. Calculate the minimum round-trip time (RTT) for the link.

b. Calculate the bandwidth * delay product for the link.

c. A camera on the rover takes pictures of its surroundings and sends these to Early. How quickly after a picture is taken can it reach Mission Control on Earth? Assume each image is 2Mbytes in size.

2. Back on earth: fiber vs the automobile

In his widely read networking textbook from the 1980's Andrew Tanenbaum wrote "Never underestimate the bandwidth of a station wagon full of tapes hurtling down the highway". Lets consider this. No one owns station wagons anymore, but a Honda CR-V has about 35cubic feet of volume in the back. An HP DAT 320 tape holds 160Gigabytes of data in a space that is roughly 2inchesx3inchesx0.5inches. Ok, so assume that we're trying to migrate data from Google's data center in the Dalles, Oregon to their data center in Douglas County, Georgia (a distance of 2500 miles by road). We have two choices: load up our CR-V with tapes and drive (assume an average speed of 50mph and no sleep – Google has driverless cars after all) or send the data over Google's dedicated fiber network which can send at 100Gbps (100 Gigabits per second). So here's the question (finally): assuming they only care about complete transmissions, how much data does Google need to send before it makes sense to send a single CR-V filled with tapes instead of using the network to transfer the data.

Time to get there: 2500/50mph = 50 hours or 180,000 seconds.
Network can transfer 12.5GB in a second, to average the same rate car would need to carry ***2,250,000GB*** *(2.25PB).*

Can the CR-V carry this much?
*How many tapes fit in the car: 6*4*24=576 tapes/cf; 20160 in 70cf*
*Storage of the car: 20160*160 = 3,225,600GB (i.e., over 3PB)*
So yes.

For fun: Max bw of CR-V transfer: 17.92GB/second = 143.36Gbps

3. Cable modem

A modern cable modem transmits using 6Mhz bandwidth channels and if the cable plant is in good order the signal to noise ratio (SNR) will be at least 30db. Note: it is common to use the logarithmic decibel scale for SNR. To convert between the decibel scale and the raw S/N ratio: $SNR_{db} = 10\log_{10}(S/N)$ (i.e., 30db = a S/N of 1000). Based on what you know of Shannon's law, what is the maximum bandwidth we could expect from a single such channel.

$6Mhz * \log_2(1 + 1000) = 6M * 9.965784 = 59,803,357$ Mbps (59Mbps)
(in practice we only get ~42Mbps of which ~4Mbps is overhead (framing, management, etc… DOCSIS 3.0 modems can combine channels to offer > bandwidth)

4. Stuffing

You are trying to send the following data:

0xfe 0x00 0x14 0x19 0x00 0x72 0x64 0x92

Describe how this data should be transformed using two different framing approaches:

a) Byte-level sentinel framing (where STX = 0x93, ETX = 0x92 and DLE=0x14)

0x93 0xfe 0x00 0x14 0x14 0x19 0x00 0x72 0x64 0x14 0x92 0x92

b) Consistent overhead byte stuffing (reminder, the first byte will indicate how many bytes to the first zero or 0xff if there is no zero in the first 254 bytes).

0x02 0xfe 0x03 0x14 0x19 0x04 0x72 0x64 0x92
(will also accept as correct answer with a final 0x00… although not actually necessary in COBS)