Solutions to Assignment 2

Question 1

(a) a ranging packet is used to estimate the delay and loss from the CMTS to the CM. This information needs to be made available to the DOCSIS MAC layer but not to higher protocol layers.

(b) a packet with a Google search query would be an HTTP packet originating with the user so it would have to use all of the protocols on the cable modem up to the IP layer.

Question 2

MAP frames transmitted are transmitted (broadcast) downstream, from the CMTS to the CM to inform all CM's of their time allocations on the upstream.

Question 3

Since DOCSIS upstream signals are transmitted from 5 to 42 MHz, if the cable company installs a high-pass filter that only passes frequencies above 52 MHz your cable modem will not be able to transmit an upstream signal and will not be able to establish a connection.

Question 4

During uplink ranging the CM adjusts its timing, frequency and power levels.

(i) If the timing is incorrect a CM's transmissions could overlap those of other CMs on the same channel and interfere with their transmissions.

(ii) If the frequency of a CM is incorrect it could interfere with transmissions from CMs using an adjacent channel at the same time. In addition, too-high power levels could also cause interference to CM transmissions on other channels depending on the adjacent-channel selectivity of the CMTS receiver.

Question 5

An ADSL-1 modem (ATU-R) receiver samples signals with frequencies up to 1104 kHz. Assuming the A/D converter sampling rate is 3 times this frequency the sampling rate would be 3312 kHz.

At the DSLAM, the sampling rate (assuming the same ratio of sampling rate to maximum frequency) would be 3 times 138 kHz or 414 kHz.

Question 6

For an OFDM system with a sampling rate of 4 MHz and an OFDM symbol size of 128 samples the subcarrier spacing is $\Delta f = 1/T_s = f_s/N = 4 \times 10^6/128 = 31.25$ kHz.

The sample period is $1/4$ MHz $= 250$ ns. The guard time durations that are powers of 2 (1, 2, 4, 8, ...) times the sample period would be 250, 500, 1000, 2000, 4000, ..., ns. The smallest guard time that is least 3 microseconds is 4 μs corresponding to 16 samples. This is the length of the cyclic prefix in units of samples.

Question 7

A PON system with transmitter output power of 3 dBm, maximum cable loss of 18 dB and receiver sensitivity of -25 dBm would have a margin of $3 - 18 - (-25) = 10$ dB. An ideal 8-way splitter would have a loss of 9 dB and an ideal 16-way splitter a loss of 12 dB so an 8-way splitter is the largest power-of-2 split ratio that could be used. This would only leave a margin of about 1 dB.

Question 8

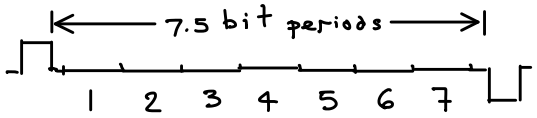
The following table shows the wireless cellular data standards and their approximate maximum downlink

data rates (these will vary greatly depending on the assumptions):

Standard	Maximum Rate
GSM (GPRS)	280 kb/s
EVDO	3 Mb/s
WCDMA / HSDPA	3-14 Mb/s
LTE (maximum)	300 Mb/s

Question 9

A T1 signal using B8ZS uses a line code that allows a maximum of eight consecutive zero bits before inserting a special sequence. Thus the maximum duration of zero signal level is seven zero bits. Since the duty cycle is 50%, the duration of a sequence of seven zero bits is seven bit period plus half of one bit period (one quarter of a bit period for each of the preceding and following ones) as shown below:



The duration is thus $7.5/1.544 = 4.86$ μs.

Question 10

Frame slips only happen on a T1 link if the transmitter and receiver clocks are running at different frequencies. This is always the case unless they are derived from the same source.

- if the transmitter and receiver use independent clocks there will be frame slips
- the receiver recovers its clock from the received signal or if the transmitter and receiver use the same clock there will be *no* frame slips.

Question 11

If a PBX reference clock accuracy is 10 ppm and the CO frequency accuracy is 10^{-11} the maximum frequency error will be approximately 10 ppm.

The time between frame slips is given by:

$$\Delta T = \frac{N}{\Delta R} = \frac{193}{1.544 \times 10^6 \times 10 \times 10^{-6}} = 12.5 \text{ s}$$

So frame slips could happen at a maximum rate of about 4 per minute.

Each frame slip results in a lost or inserted sample in a PCM stream and causes either a noise glitch or data error. Frame slips can usually be avoided by avoiding independent clocks or by synchronizing all clocks to an accurate master clock (typically derived from a GPS receiver).