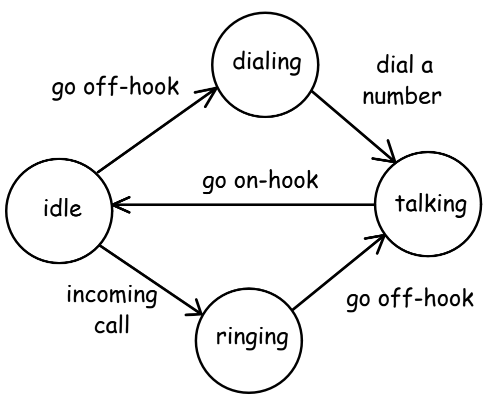
Solutions to Assignment 1

Question 1

- POTS (Plain Old Telephone Service) is provided by the PSTN (Public Switched Telephone Network).
- A DSLAM (Digital Subscriber Line Access Multiplexer) provides ADSL (Asymmetric Digital Subscriber Line) service.
- The DOCSIS (Data Over Cable Service Interface Specification) operates over a HFC (Hybrid Fibre-Co-Ax) plant.
- PON (Passive Optical Network) is an access technology.
- SONET (Synchronous Optical Network) is a standard primarily used for long-haul (rather than access) links.

Question 2

A (greatly) simplified state transition diagram for a subscriber line interface might look as follows:



Question 3

A steady 40 VDC across the pairs would indicate battery voltage and thus an on-hook condition (one conductor would be at ground voltage and the other at about −48 VDC).

A DC voltage of 0 V might indicate that the voltage between the pairs was alternating between two opposite voltages, for example, positive and negative battery voltage[1]. This would ring the phone. The period 6s (a ringing cadence of 2s on, 4s off) matches that of the North American ringing signal.

A steady DC voltage of 8V between the pairs indicates an off-hook condition.

The likely explanation is that an incoming call caused the phone to ring and the subscriber answered the call.

Question 4

(a) A HFC system will likely have more distribution amplifiers than optical nodes because the output of an optical node feeds a co-ax distribution system supplying many users, perhaps several hundred. The losses in the co-ax distribution system and the splitters need to be made up by distribution amplifiers so typically there will be many more distribution amplifiers than optical nodes.

(b) The co-ax cable going into a house typically goes from a distribution amplifier or splitter to the house. It is thus considered a drop cable.

Question 5

An output level of +4.5dBmV is 4.5dB more than 1mV. The voltage is:

$$1 \text{ mV} \times 10^{4.5/20} = 1.7\text{mV}$$

This corresponds to a power across an impedance of 75 ohms of:

$$\frac{V^2}{R} = \frac{(1.7 \times 10^{-3})^2}{75} = 38\ \mu\text{W}$$

or

$$10 \times \log_{10}(38 \times 10^{-3} \text{ mW}) = -44 \text{ dBm}$$

[1] Another possibility for a ringing waveform is a ringing voltage superimposed on battery voltage.

Question 6

(a) Assuming a symbol rate of 1.28 MHz with QPSK modulation, the upstream data rate in bits/second is:

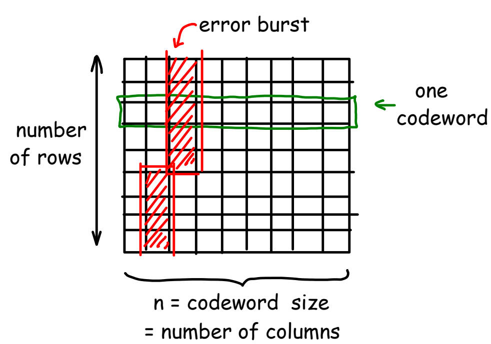
$$1.28 \times 10^6 \text{ symbols/s} \times 2 \text{ bits/symbol} = 2.56 \text{ Mb/s}$$

$$2.56 \text{ Mbits/s}/8 \text{ bits/byte} = 320 \text{ kBytes/s}$$

(b) If the length of each error burst is 100 microseconds, the length in bytes is:

$$100\ \mu s \times 320 \times 10^3 \text{ bytes/second} = 32 \text{ bytes}$$

(c) Data is read out of the interleaver down each column and each row corresponds to one codeword (this is part of the DOCSIS specification). To ensure no more than one error per codeword (one error per row) we need at least 32 rows. The diagram below shows an example of how an error burst duration equal to the number of rows results in one error per codeword:



(d) To maximize the code rate, k/n, we want to make the codeword size, n, as large as possible. The codeword size, n, is also the interleaver width. Since the maximum interleaver size is 2048 the maximum codeword size is $n = 2048/32 = 2^{11}/2^5 = 2^6 = 64$ bytes.

To ensure each codeword can correct one error, we need to have at least two parity bytes per codeword thus $n - k = 2$ and $k = 64 - 2 = 62$. The code rate is $R = k/n = 62/64 = 0.97$.

(e) The delay to fill the interleaver is:

$$\frac{2048}{320 \times 10^3} = 6.4 \text{ ms}$$

To limit the delay to 2 ms the maximum interleaver size would be:

$$320 \text{ kBytes/s} \times 2 \text{ ms} = 640 \text{ bytes}$$

with a codeword size of

$$n = \frac{640}{32} = 20 \text{ bytes}$$

with $k = 20 - 2 = 18$ and a code rate $R = 18/20 = 0.9$.