SYSC 4700 Midterm Exam Winter 2005

Question 1

(a) Describe the DS1 system, showing how it converts voice signals to digital signals and multiplexes 24 of them into a 1.544 Mb/s bit stream. In your answer, comment on the choice of sampling rate, quantizing method and bit rate.

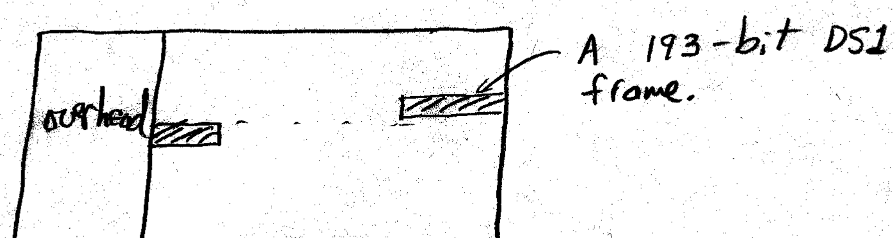
Each of the 24 voice signals is filtered to a bandwidth of about 3.4 kHz. The sampling rate is 8 kHz - according to the sampling theorem, the rate must be at least twice the signal bandwidth. Each sample is quantized into 256 ($256 = 2^8$, so 8 bits/sample) non-uniformly spaced levels, to achieve a satisfactory dynamic range. 24 8-bit coded samples, plus a single framing bit, give $24 \times 8 + 1 = 193$ bits in a DS1 frame, transmitted every 125 μs (i.e. 8000 times/s.) for a total bit rate of $193 \times 8000 = 1.544$ Mb/s.

(b) Describe how a 1.544 MB/s DS1 stream is carried within a 51.84 Mb/s SONET STS-1 signal.

Each DS1 frame is carried intact, as part of the SONET STS-1 frame:

e.g.

A SONET frame:



The pointer overhead part of the SONET frame overhead points to the start and end of the DS1 frame, so that the DS1 frame can be removed and inserted easily.

Question 2

(a) Describe how the Erlang B formula for blocking probability is used in telecommunication system design problems. You should use an example in your answer. (You need not write down the formula).

The Erlang B formula gives relationship between:

(1) blocking probability

(2) total traffic intensity (Erlangs)

(3) number of lines or trunks needed for this blocking prob. and intensity.

Given any 2 of these, the third can be found.

It can be used to determine required number of lines (as in example of part (b)), assuming call arrivals are Poisson-distributed, call durations are exponentially distributed, and that blocked calls are cleared.

(b) Suppose a pair gain system concentrates 1000 individual subscriber loops onto N DS1 signals to a central office. Each subscriber loop is assumed to have an average busy hour traffic intensity of 0.1 Erlangs, and the blocking probability is to be no more than 1%. Determine the minimum value of N.

Total traffic intensity = 1000 loops × 0.1 Erlangs per loop
= 100 Erlangs

From Erlang B table, for blocking prob. = 0.01 = 1%,

99.21 Erlangs requires N = 116 lines.

101.1 Erlangs requires N = 118 lines.

So minimum N is 117 lines or channels

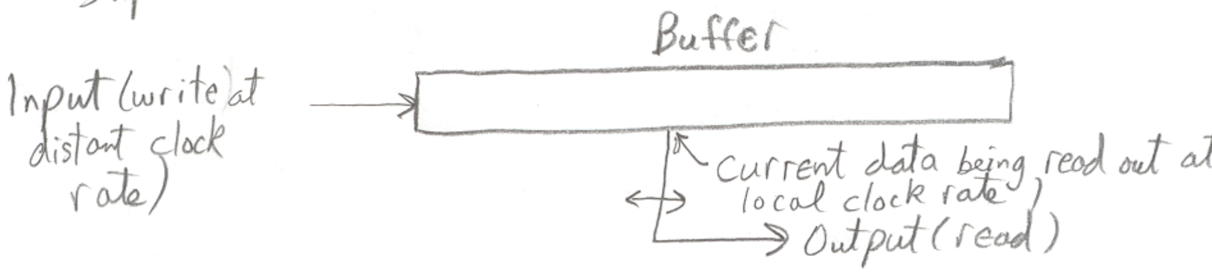
Since a DS1 signal carries 24 channels,

int(117/24) = **5 DS1s are required.**

Question 3

(a) Explain what is meant by a slip, and how buffering reduces the frequency of ocurrence of slips.

Data from a distant central office enters a buffer at the distant CO's clock rate. It is removed from the buffer at the clock rate of the local central office. If these two clock rates differ, the buffer will eventually overflow (if the local clock is slower) or underflow (if the local clock is faster). With overflow, data is lost, with underflow, data is repeated. Either case is called a slip. The longer is the buffer, the longer the time between slips.



(b) For a primary reference clock source, that has a clock accuracy of one part in 10^{11}, a two-frame buffer for DS1 signals experiences a slip about once every 74 days, on the average. Prove this statement by computing the slip rate.

Clock frequency at each end $= (1.544\times10^{6})(1 \pm 10^{-11})$ Hz.

So max. frequency difference between the two clocks

$= \Delta f = 2 \times 1.544\times10^{6} \times 10^{-11}$ Hz

For a 2-DS1-frame buffer,* a slip occurs once one clock gains or loses 1 frame = 193 bits relative to the other.

So $(\Delta f = 2\times1.544\times10^{-5}) \times (\text{time in sec.}) = 193$

$$\text{time} = \frac{193}{2\times1.544\times10^{-5}} = 6.25\times10^{6} \text{ s.} = \frac{6.25\times10^{6}}{24\times3600}$$

$$= \boxed{72.3 \text{ days.}}$$

* Pointer starts in middle of 2-frame buffer.

Question 4

(a) Give three examples of <u>successful</u> telecommunications standards. For each, describe what it is, and why and in what sense it is successful.

There are <u>many</u> successful standards that could be chosen. For example:

<u>SS7</u> (CCS7) Signalling system #7 - separate packet-network-based system for setting up calls. Used worldwide. Facilitates new services.

<u>GSM</u> - cellular system. Used worldwide - allows worldwide roaming for cellular customers. 100's of millions of low cost GSM-based cell phones in service.

<u>TCP-IP</u> - basis of email and the internet.

Others: SONET, Ethernet, AMPS, IEEE 802.11, ----

(b) Briefly describe the value of telecommunications standards to **ONE** of the following: (1) telecom users; (2) telecom equipment manufacturers; (3) telecom service providers.

(1) Telecom users: - compatibility of user equipment with that of other manufacturers.
- low cost due to large production runs.

(2) Equipment manufacturers - larger market for standardized ~~prod~~ products; also lower production costs
- knowledge of industry trends & customer requirements.

(3) Service providers - Consistent, well-defined interfaces with customers and other service providers.
- Multiple sources of supply.