94.521 Homework assignment 1

Due Feb. 12th

1. Calculate the DS1, E1, T1c, and E3 rates.
2. Assume that the F-bit consists of repetitious code 10010110. Assume also that a synchronization function tries to find this pattern in the data stream so that it can frame synchronize with it.
   (a) Is there a probability that this pattern may also be emulated in the data stream
   (b) If the answer to part a is yes, comment on whether synchronization may be achieved.
3. Determine why the bit rate of the F-bit in the DS1 signal is 8 Kbps.
4. What is the rate of a superframe?
5. Consider a video source that produces a periodic VBR stream with the following "on-off" structure. The source is "on" for 1s with a rate of 20 Mbps; it is then "off" for 2s with a bit rate of 1 Mbps.
   (a) What are the peak and average rates of this source? Suppose this source is served at a constant bandwidth of c Mbps where c is is larger than the average rate. Calculate the buffer size $b{=}b(c)$ in MB needed to prevent any loss as a function of c. What is the queuing delay as a function of c?
   (b) If this traffic is produced by a videoconferencing application, which permits a maximum delay of 200 ms, what should c be?
   (c) If this traffic is produced by a video server that is downloading a 1 hour-long video program, how much disk storage do you need? suppose you want to play the program, but disk access rate is only 10 Mbps. How many parallel disks would you need, and how would you store the video program on the disk?
   (d) In the description above, the period of the source is 3s, and there is a duty cycle of 1/3. Consider another source with the same duty cycle but with a smaller period. Would you say the second source is more or less bursty? Why?
6. Consider K telephone sets that share $N \leq K$ outgoing lines of a PBX. Assume that each telephone generates a new call, when it is not busy, as a Poisson process with rate ρ . Calls have independent holding times that are exponentially distributed with rate 1. Model the number of calls in progress by a Markov chain and calculate the

probability that the N lines are busy. Relate that probability to the probability that a call is blocked. Are these probabilities the same?

7. Let $\{A_t, t \geq 0\}$ be a Poisson process with rate λ . Define the processes $\{B_t, t \geq 0\}$ and $\{C_t, t \geq 0\}$ as follows. At each arrival time of $\{A_t, t \geq 0\}$, one flips a coin. With probability p, the outcome is heads and the arrival time is defined to be an arrival time of $\{B_t, t \geq 0\}$. Otherwise, that arrival time is defined to be an arrival time of $\{C_t, t \geq 0\}$. Show that the processes $\{B_t, t \geq 0\}$ and $\{C_t, t \geq 0\}$ are independent Poisson processes with rate λp and $\lambda(1-p)$, respectively.
8. Prove that the time a Markov Chain spends in any state is a random variable that follows the exponential distribution

- From Saadawi et al.: Problems 3.1, 3.3, 3.6, 3.13, 3.17
- From Walrand et al.: Problblmes 15 and 18 on page 485.