EE 550 Fall 2011 PROJECT

Due: Noon, MONDAY December 5th, 2011.

The objective of this project is to simulate a simple packet voice system at 3 levels.

Consider a set of N packet voice devices that all share a common communication channel (the access link) that feeds into a switch which is part of the public network. You are studying the access link. which has a maximum data rate of C bps. You should run your simulation at least for the cases of $N = 10{,}100{,}1000$ and $C = 1.54 Mbps$ (a T-1 line which corresponds to 24 x 64Kbps circuits.)

Level 1 (Call level): The call or connection level. Each user/device is in one of two states: Idle or Connected. Connected indicates that the user is engaged in a conversation; and idle indicates that the user is currently not engaged in a conversation. The user stays in the Idle State for an exponentially distributed time, with mean $1/\lambda$ minutes, until it transitions to the Connected State. The time that the user is in the Connected state has a general distribution, CDF $F_X(x)$ distributed with mean $\overline{X}$ minutes. Typical values for these parameters are $\overline{X} = 3$ minutes and $1/\lambda = 30$ minutes.

Write a simulation to model this system. The program should handle the following cases:

a) X is a constant. This corresponds to all calls lasting exactly the same amount of time.

b) X is exponentially distributed. For this case you can also generate analytical results to verify that your program is working correctly.

c) X has a bi-modal distribution: $P(X = 1) = 0.8; P(X = 11) = 0.2$, note that $E[X] = 3$

You should use the program to determine the distribution of the number of calls in progress at a random point in time. Your program should also report on the mean and variance of the number of calls in progress at a random point in time. [Extra Credit: Can you also give 95% confidence intervals for the mean and the variance?]

When modeling only level 1, you should consider that the maximum number of connections that can be active at one time is 24. In this case you should also report on the number (and fraction) of calls accepted and blocked.

Level 2 (Voice-spurt level): In the Connected State, a user is communicating (talking). However, the speech is not continuous. It is usual to model that the user has two states {silent} and {active} which can modeled as a Markov chain characterized by the mean time spent in the silent state as second $\overline{T}_{silent}$ and the mean time spent in the active state as $\overline{T}_{active}$ seconds (note that the state residence time will be exponentially distributed since it is specified as a Markov chain). Typical values are $\overline{T}_{silent} = 1$ and $\overline{T}_{active} = 0.5$ seconds although this varies depending on the language and country of origin of the user. Building on top of you level 1 model, use your simulation to find the distribution of the number of users in *silent* and *active* mode at a random point in time; also report on the mean and variance of the number of users in active mode at a random point in time. [Extra Credit: Can you also give 95% confidence intervals for the mean and variance?] For case b) at level 1, can you find the distribution of number of users in active mode analytically (this may require numerical solution)? Note when we include modeling at the talkspurt level the restriction on no more than 24 concurrent connections does not apply..

Level 3 (Packet Level): When in active mode, the user generates packets of voice samples. The packet has a 200 bit header and contains 100 voice samples and each sample is 8 bits, so the total packet length is 1,000 bits and a single active source will generate 80 voice packets per second. For a particular source the packets will be regularly spaced (when is active mode) with a spacing of 1/80 seconds (12.5 ms). These packets are fed into a statistical multiplexer that puts them in a buffer and then transmits them over the output channel. The buffer has enough space for $M = 100$ packets (this number is fairly small to prevent the introduction of large delays.) Your simulation should find the buffer occupancy distribution, the mean and variance of the buffer occupancy, the mean and variance of the waiting time, and the packet drop rate (due to queue overflows).