Solutions to Homework Set 1

Homework Problems

1. The sharing of a single link/wire by a number of connections simultaneously is multiplexing. The improvement in the system design comes through the requirement of lesser resources by allowing users to share a common transmission medium instead of having separate wires for each one of them. (6 pts)

Statistical multiplexing gain depends on the difference of the peak and the average transmission rates. Since average transmission rate of bursty traffic is lower than its peak rate, more users can share a link without performance degradations. If load characteristics have no variations (i.e. non-bursty traffic) then peak rate $\approx$ average rate and the number of users that can be supported cannot be increased. (7 pts)

Packet switching offers the following advantages:
(1) better sharing of bandwidth that circuit switching
(2) simpler, more efficient (through statistical multiplexing) and less costly than circuit switching (7 pts)

2.

(a) With circuit switching, how many users can be supported? (5pts)

ANS. 10 users

(b) Now consider packet switching with 50 users. What is the probability that **exactly** 10 users are active? (7.5pts)

ANS.

$$\binom{50}{10}(0.25)^{10}(0.75)^{40} = 0.0985$$

(c) What is the probability that **at least** 10 users are active? (7.5pts)

$$\sum_{i=10}^{50} \binom{50}{i} (0.25)^i (0.75)^{50-i} = 1 - \sum_{i=0}^{9} \binom{50}{i} (0.25)^i (0.75)^{50-i}$$
$$= 0.8363$$

(d) What is the maximum number of users that can be supported on the link with packet switching assuming we do not want the probability that 10 or more users are active to be greater than 0.05? (10pts)

ANS. You get it by solving for N in

$$\sum_{i=10}^{N} \binom{N}{i} (0.25)^i (0.75)^{N-i} < 0.05$$

which yields $N = 23$.

3. Concepts: **(Layering)**

(a) (12.5pts)

You *cannot* have peer to peer communication in a layered environment, *except* for the physical layer. All other layers must go through their lower layers before they can talk to their peers.

(b) (12.5pts)

The service interface defines the operations on this layer's protocols. It acts as the interface between two adjacent layers. The layers implement their functions by adding headers to the data they get from the upper layers and relying on the services of the layers below.

Additional questions for 600 level students

1. (25pts)

It takes LN/R seconds to transmit the N packets. Thus the buffer is empty when a batch of N packets arrive. The first of the N packets has no queueing delay. The second packet has to wait till the first packet is served, i.e. L/R seconds. The third packet has to wait till the first two packets are served. Thus it wait for $2L/R$ seconds and so on. The nth packet has to wait for the first $N-1$ packets to be served, i.e. $(N-1)L/R$ seconds. Thus

$$
\begin{aligned}
\text{Average Delay} &= \frac{1}{N}\sum_{n=1}^{N}(n-1)\frac{L}{R} \\
&= \frac{L}{R}\frac{1}{N}\sum_{n=1}^{N}(n-1) \\
&= \frac{L}{R}\frac{N-1}{2}
\end{aligned}
$$

People who haven't figured out the logic don't get any points.