Solve these problems (From Chapter-1 of the Textbook)

P9. Consider the discussion in Section 1.3 of packet switching versus circuit switching in which an example is provided with a 1 Mbps link. Users are generating data at a rate of 100 kbps when busy, but are busy generating data only with probability p=0.1. Suppose that the 1 Mbps link is replaced by a 1 Gbps link.

a. What is *N,* the maximum number of users that can be supported simultaneously under circuit switching?

b. Now consider packet switching and a user population of *M* users. Give a formula (in terms of *p*, *M*, *N*) for the probability that more than *N* users are sending data.

P13.

a. Suppose *N* packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length *L* and the link has transmission rate *R*. What is the average queuing delay for the *N* packets?

b. Now suppose that *N* such packets arrive to the link every *LN/R* seconds. What is the average queuing delay of a packet?

P16. Consider a router buffer preceding an outbound link. In this problem, you will use Little's formula, a famous formula from queuing theory.

Little's Formula

*Let N denote the average number of packets in the buffer plus the packet being transmitted. Let **a** denote the rate of packets arriving at the link. Let **d** denote the average total delay (i.e., the queuing delay plus the transmission delay) experienced by a packet. Little's formula is **N = a * d**.*

Suppose that on average, the buffer contains 10 packets, and the average packet queuing delay is 10 msec. The link's transmission rate is 100 packets/sec. Using Little's formula, what is the average packet arrival rate, assuming there is no packet loss?

P1. Design and describe an application-level protocol to be used between an ATM and a bank's centralized computer. Your protocol should allow a user's card and password to be verified, the account balance (which is maintained at the centralized computer) to be queried, and an account withdrawal to be made (that is, money disbursed to the user).

Your protocol entities should be able to handle the all-too-common case in which there is not enough money in the account to cover the withdrawal. Specify your protocol by listing the messages exchanged and the action taken by the ATM or the bank's centralized computer on transmission and receipt of messages. Sketch the operation of your protocol for the case of a simple withdrawal with no errors, using a diagram similar to that in the figure below. Explicitly state the assumptions made by your protocol about the underlying end-to-end transport service.

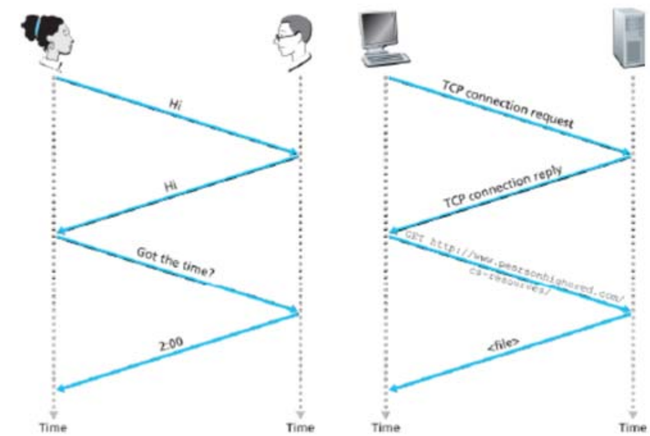

Figure 1.2 A human protocol and a computer network protocol