**INST 346 H1 Networks Basics**

**\* XCY is the same as X choose Y**

1. Suppose users share a 3 Mbps link and each user requires 150 kbps when transmitting. Each user, however, only transmits with probability p=0.1 (i.e., 10 percent of the time).
	1. If circuit switching is used, what is the maximum number of users the link can support?

**3000 kbps / 150 kbps = 20 users**

* 1. For the remainder of this problem, suppose packet switching is used and that the users are acting independently (in the statistical sense, so for example two users transmit at the same time with probability p\*p). What is the probability that a given user is transmitting?

**p = 0.1 , easy one ☺**

* 1. Suppose the network contains 120 users. What is the probability that, at any given time, exactly N users are transmitting simultaneously? (Hint: Use the binomial distribution. If you need a reminder of the formula for the binomial distribution, [Wikipedia](https://en.wikipedia.org/wiki/Binomial_distribution) might be helpful).

**P (N users are transmitting) = P(X=N) = 120 CN \* 0.1N \* (1-0.1)(120 –N)**

* 1. The network would reach capacity if 20 (=3M/150k) users were to be sending at the same time. What is the probability that 21 or more users are transmitting simultaneously?

**P (>21 users transmitting) = P(X>21)=** $Σ$**n=21 to 120 120 CN \* 0.1N \* (1-0.1)(120 –N)**

**This amounts to about 0.0079 (you can calculate using a calculator / code), which is very small.**

* 1. Now consider a network of M users. Give a formula in terms of p, M, and N for the probability that N or more users are sending data at the same time.

**P(X>=N) =** $Σ$**n=N -> M (MCn \* pn \* (1-p)(M –n))**

1. Use these results and your understanding from the reading and our class discussion to help you answer the following questions.
	1. What are the advantages of circuit switched network over a packet switched network?

**Simple sharing rules, guaranteed bandwidth/ transmission rate. No waiting, queuing delays/ congestion. In the above problem, 3 Mbps transmission rate is guaranteed for all the 20 users the network can accommodate.**

* 1. What are the advantages of packet switched network over circuit switched network?

**Better resource sharing, accounts for idle users and can support many users in the same infrastructure. Packet switching is useful when the probability that multiple users transmit simultaneously is small, as in the above problem. Circuit switching can only accommodate 20 users while packet switching could accommodate a lot more.**

1. We saw in equation (1.1) in Section 1.3.1 that d = N\*L/R is the formula for end-to-end delay for sending one packet of length L over N links, each with transmission rate R, when store-and-forward packet switches are used (ignoring queuing, propagation delay, and processing time). Generalize the formula for sending K such packets back-to-back over the N links. Explain.

**Store and forward framework - by the time a packet reaches the destination, the following packet is stored in the router adjacent to the destination and so on. So each packet after the first only has L/R delay.**

**Delay = N\*L/R + (L/R) -> (K-1) times = (N+K-1)\*L/R**

1. Suppose there is exactly one packet switch between a sending host and a receiving host, the transmission rates between the sending host and the switch and between the switch and the receiving host are R1 and R2, respectively and that the switch uses store-and-forward packet switching. What is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.) Explain.

**Sending host to switch, the transmission delay is (L/R1).**

**Switch to receiving host, the transmission delay is (L/R2).**

**Total delay is the sum of the two.**

**Delay = (L/R1) + (L/R2)**

1. Suppose you need to deliver a 40-terabyte dataset from Boston to Los Angeles. You have available a 100 Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use FedEx over-night delivery to send a set of disk drives? Explain. Be careful with the difference between bytes (B) and bits (b) when answering questions involving transmission rates.

**40 terabytes = 4 \* 1012 \* 8 bits; 100 Mbps = 100 \* 106 bits per sec**

**If using the dedicated link, it will take 40 \* 1012 \* 8 / (100 \* 106) = 32 \* 105 seconds = 37 days. But FedEx overnight delivery, you can guarantee the data arrives in one day and it should cost less than $100.**