CS 164 Fall 1994

Final Examination

3 Hours, Closed Book
Aids allowed: Calculator

I. Briefly explain the following terms: (i) isarithmic flow control; (ii) choke packet; (iii) idle token; (iv) Hamming distance; (v) idempotency; (vi) quarantining.

II. Name three methods for controlling congestion in packet-switched networks. Describe each one using a few sentences. For each method, state whether or not it is equally good for virtual circuit and datagram networks.

III.

a. For a binary message `1001011101001111`, compute its CRC code using the polynomial $x^8 + x^7 + x^2 + 1$. Your should use long division method to solve it.

b. For CRC encoding, The long division method is not suitable for programming. Describe a simpler algorithm using a 8 bit shift register to solve this problem. You don't need to re-do the computation, just describe the algorithm in a high level language.

IV. Alice is trying to send a long sequence of fixed-length frames to Bob over a data link that uses Go-Back-N. Assume that errors occur *deterministically,* once every ten frame transmissions from Alice to Bob, and that there are never any errors on the acknowledgements. Also assume that Alice receives the ACK or NACK for the frame she sent at time T just before she must decide which frame to send at time $T + N$.

a. What transmit window size should Alice use? Your answer should be a function of N.

b. Trace what Alice does during the first 25 time steps, assuming that $N = 5$.

c. What is the channel efficiency as a function of N?

d. What happens when $N = 10$?

e. What happens when $N > 10$?

V. You have been asked to set up a three-node network connecting some host computers located in Los Angeles, Riverside and San Diego. Assume that all packet lengths are exponentially distributed with a mean of 1200 bits, and that two configurations of equivalent cost are possible. First, three 4800 bps lines could be used, allowing direct connections between each pair of hosts. In this case, all traffic will be sent over the direct line. Second, two 9600 bps lines could be used, one connecting Los Angeles with Riverside, and the other connecting Riverside with San Diego. In this case, traffic between Los Angeles and San Diego must be sent via Riverside. The traffic matrix that this network must support is shown below.

	L	R	S
L	-	2	3
R	3	-	2
S	1	3.5	-

a. What is γ for this system?

b. Draw both networks and indicate the flow each channel in each case.

c. Find the average path length.

d. Find the overall mean packet delay in each case.

e. [Bonus question — the answer is short but it's tricky]

You should have found that three-line design had a higher delay than the two-line design. Since alternate routing is possible with three lines, and since there was no effort to optimize the routing, your boss asks whether your answer to part (a) is valid. Give a convincing argument to show him that no amount of rerouting of traffic would make the overall mean packet delay for the three-line design as small as the delay for the two-line design?

VI. The next generation of Metropolitan Area Networks (MANs) is expected to run at data rates in excess of 1 Gbit/sec (i.e., 10^9 bps) and span distances on the order of 100 kilometres.

a. For CSMA/CD to work properly, the transmission time for a packet needs to be at least twice the end-to-end propagation delay across the network. Assuming a propagation speed of 2×10^8 metres/sec. through optical fibre, what would be the minimum packet size for CSMA/CD on such a Gigabit MAN?

b. What is the maximum throughput that a single station could achieve using 10,000 bit packets on a 1 Gbit/sec. token ring, assuming ordinary service (i.e., one packet per visit of the token) and a total ring circumference of 200 kilometres?

c. The most likely architecture for this type of Gigabit MANs uses small packets (roughly 500 bits, for compatibility with ISDN switches), and a medium access control protocol vaguely similar to the slotted ring. How many slots would there be on a 200 kilometre ring? How large a window size would be required to allow the sender to keep going without stopping? How practical would the Selective-Repeat ARQ be in this application?

VII. Consider an error recovery technique where, in the event of an error, you don't repeat the damaged packet. Instead you send blocks of extra error correction information that can be combined with the damaged packet to repair the damage. Under this scheme, assume that the initial transmission will contain an error with probability 1/2. If there is an error, the sender will send a first block of extra error correction information that will allow the receiver to correct the damaged packet with probability 3/4. And, if there is still an error, the sender will send a second block of extra error correction information that is guaranteed to correct the damaged packet.

a. What is the average service time for a packet, assuming it takes 1 second to transmit each packet or block of error correction information, and that the time until the receiver returns an acknowledgement is negligible?

b. If the arrival rate of new packets is 0.4 packets/second, what is the average packet delay in this system?

FORMULAS: $\rho = \dfrac{\lambda}{\mu}$; $\quad \sum_{j=0}^{\infty} x^j = \dfrac{1}{1-x}$ if $|x| < 1$.

M/M/1: $\pi_k = (1-\rho)\,\rho^k$; $\quad \bar{N} = \dfrac{\rho}{1-\rho}$; $\quad \bar{T} = \dfrac{1/\mu}{1-\rho}$;

Mean Residual Life: $\dfrac{\overline{X^2}}{2\,\bar{X}}$; $\quad$ M/G/1: $\bar{T} = \dfrac{1}{\mu} + \dfrac{\lambda\,\overline{X^2}}{2\,(1-\rho)}$;

Network Delay: $T = \dfrac{1}{\gamma} \sum_l \dfrac{\lambda_l}{C_l - \lambda_l}$; $\quad \dfrac{\partial T}{\partial \lambda_l} = \dfrac{C_l}{(C_l - \lambda_l)^2}$;