Gary Chan
Fall 2001

COMP 361 — Computer Communication Networks I

Midterm Examination

Thursday, October 18, 2001

OPEN BOOKS / OPEN NOTES
7:30pm – 8:45pm (75 minutes)

NAME : ______________________________

Student ID : ______________________________

Assigned Grade: **1)___(/20)** **2)___(/30)** **3)___(/25)**
Total: _____ **/ 75**

Problem 1: CRC *(20 points)*

A CRC code uses the generator polynomial $G(x) = x^3 + 1$.

a) *(5 points)* Can it detects all single error? Explain.

b) *(5 points)* Can it detects all odd number of error? Explain.

c) *(5 points)* Can it detects all burst error of length 3? Explain.

d) *(5 points)* Suppose the error polynomial is $E(x) = 100001$. Is the error detected? Explain.

Problem 2: Error Detection vs. Error Correction *(30 points)*

Station A has infinite data to be sent to station B via an unreliable link. Bit error occurs independently with probability α.

For error control, a fixed number of redundant bits are added to every m user bits to form a frame which is then put into the channel. A data frame received in error is retransmitted until it is successfully received. Therefore, A continuously transmits to B data frames, some of which are new while the rest are re-transmitted frames. Assume that the processing delay is negligible.

a) *(12 points)* Suppose error detection code is used. In this case, r redundant bits are introduced in each frame to detect any possible frame error.

   i) *(3 points)* Let P_d be the probability that a data frame received is in error. Express P_d in terms of m, r and α.

   ii) *(5 points)* Find the average number of transmissions $E[N]$ (including the first transmission) for a frame to be received correctly in terms of m, r and α.

   iii) *(4 points)* Express the normalized data throughput (excluding the redundant bits) in terms of m, r, and α.

b) *(10 points)* Suppose now error correction coding is used. In this case, h redundant bits are introduced in each frame to detect all bit errors and correct a single bit error if it occurs.

i) *(3 points)* Let P_c be the probability that a data frame received is in error after error correction. Express P_c in terms of m, h and α.

ii) *(4 points)* Find the average number of transmissions $E[S]$ (including the first transmission) for a frame to be received correctly in terms of m, h and α.

iii) *(3 points)* Express the normalized data throughput (excluding the redundant bits) in terms of m, h and α.

c) *(8 points)* Tabulate your normalized throughput in the following, using $m = 1000$ bits, $r = 10$ bits, and $h = 100$ bits.

i) *(4 points)* For $\alpha = 10^{-5}$:

$\alpha = 10^{-5}$	Error detection	Error correction
Normalized throughput		

Which control scheme has higher throughput?

ii) *(4 points)* For $\alpha = 0.001$:

$\alpha = 10^{-3}$	Error detection	Error correction
Normalized throughput		

Which control scheme has higher throughput?

Problem 3: Burst Error *(25 points)*

In class, we have covered the use of Hamming code to correct infrequent burst of bit errors (Ref. HO#4, p. 14). Briefly speaking, B blocks of data are first collected, then Hamming-coded, arranged, and finally transmitted over the network. Point A is to transmit to point B via a single link of propagation delay τ using this method.

Let m be the number of data bits and r be the number of Hamming parity bits in a data block. The data is generated in a continuous manner (as in video or audio applications) at W bits/s, which is also equal to the channel bandwidth between point A and point B.

We show in Fig. 1 the time-space diagram of the transmission, in which the block formation time is the time to collect B blocks of data before they are transmitted over the channel. Note that at the receiver all the B data blocks have to be received before the data can be decoded and playbacked. We have assumed that the coding and decoding time is negligible. Let D be the total delay from the time a bit is generated till the time it is playbacked.

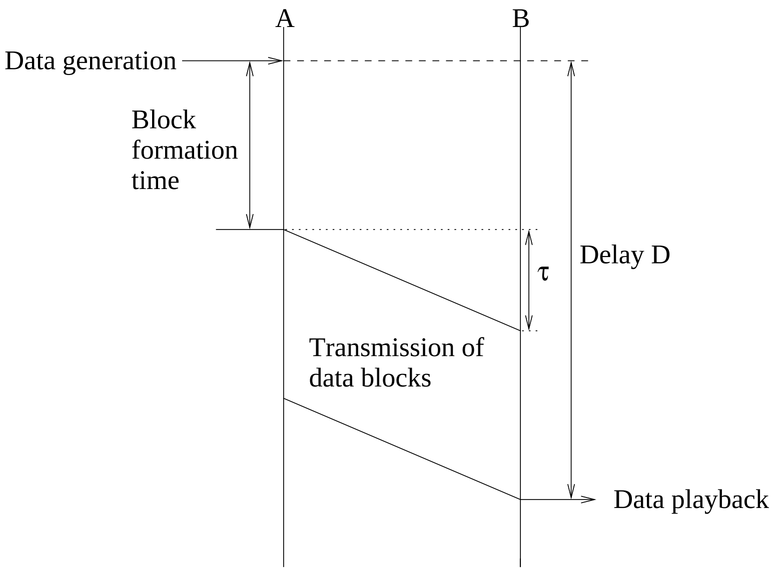

Figure 1: The time-space diagram for error correction of infrequent error burst.

a) *(10 points)* Express D in terms of B, W, m, r, and τ.

b) *(15 points)* Let $B = 10$, $W = 100$ kb/s, and $\tau = 10$ ms. Suppose a delay $D \leq 500$ms is to be guaranteed. Find the largest m and the corresponding r to satisfy that. (Hint: you may find the formula $m \approx 2^r$ for Hamming code useful here.)

Blank page for rough work or continuation of work